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Fig. 1.

THE WATER METRE,

AND THE

ACTUAL MEASUREMENT SYSTEM

OF

CHARGING FOR PUBLIC WATER.

BY

FRANK G. JOHNSON, M. D.,

BROOKLYN, N. Y.

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PREFACE

Every possible method of adjusting Water Rates has been tried, and every system having failed to satisfy either the Supplier or the Consumer, or both, the only plan which now remains to be adopted, that will prove reliable and just, and therefore satisfactory to all, is that of Actual Measurement.

As this can be accomplished only by means of Water Metres; and as there are, in consequence of the novelty of such metres, many erroneous views in regard to their application, we propose, in order that the subject may be more correctly appreciated, particularly by the consumers of public water, to set forth in the following pages the leading ideas connected with the *Actual Measurement System of Charging for Public Water.*

CONTENTS.

PAGE

MAGNITUDE OF THE GENERAL SUBJECT 7

REASONS WHY WATER METRES SHOULD BE ADOPTED 8

1st. They are in keeping with the principles which govern all buying and selling 8

2d. To prevent the waste of water ..... 9 to 21

Methods of waste, and illustrations given to show the amount of waste: 1*st. By the general method of plumbing*—2*d. By flow of water to prevent its freezing*—3*d. Water-closets and urinals*—4*th. Steamboats*—5*th. Sprinkling streets and yards, washing windows and houses, &c.*—6*th. Building*—7*th. Stables*—8*th, Manufactories, breweries, &c.*—9*th. Amusement for children*—10*th. Motive power* ..... 21 to 28

The probable PERCENTAGE *and* INCREASE *of waste* 28

Table showing average daily consumption, in ten cities, for each INHABITANT, *each* CONSUMER, *and each* TAKER; *and percentage of population using water* 29, 30

The present methods of preventing waste ..... 31 to 33

Metres would make every taker a SELF-INTERESTED GUARDIAN *of the Works* ..... 33 to 34

Metres, according to the opinions of Water Boards, the ONLY *remedy against waste* ..... 35 to 38

3d. To insure JUSTICE and SATISFACTION to all 38

The methods now in use for fixing rates, and their fallacy ..... 39 to 42

Evidences from Water Reports to show the injustice of the present systems ..... 42 to 48

Statistics showing difference in amount of WATER CONSUMED, *and* REVENUE RECEIVED, WITH *and* WITHOUT *metres* 48, 49

4th. To render water works more efficient 49

1*st. By keeping greater head in the reservoirs* 49

2*d. By increasing the force of head in the pipes* 49

3*d. By insuring greater head and quantity of water in case of fire* 49

4*th. By affording water for public fountains, baths, &c.* 50

5th. To save main conduit from danger ..... 53 to 56

6th. To render extensions of water works unnecessary ..... 56 to 58

7th. To enable smaller towns and cities to afford public water ..... 58 to 60

PAGE

8th. To prevent the poisonous corrosion of lead pipes..... 60
9th. To cheapen the price of water for all, especially for manufacturing, &c.....61 to 63
10th. To regulate price of water to meet its cost..... 63
11th. To facilitate the changing of rates..... 63, 64
12th. To increase the revenue without increasing the rates charged.64 to 67

FANCIED OBJECTIONS TO THE METRE SYSTEM..... 68

1st. Some think water should be free as air to all..... 68
2d. Others think they will be charged more *with* than without metres—that they cannot afford to pay by the *gallon*, &c.....68 to 71

ACTUAL COST *of water compared with* PRICE CHARGED..... 71

Table, showing number of gallons different sums (from $1 *to* $21*) would buy at* COST PRICE, *and the* PRESENT PRICE..... 72

The cost of pumping public water..... 74

3d. Some say metres would make additional and useless expense..... 75
4th. It is said they would be turned to political account..... 76
5th. That the Metre Inspectors would collude with consumers, and return false reports..... 76
6th. Others say metres would be tampered with by consumers..... 77
7th. It is said metres will freeze up, &c..... 77
8th. Some say metres are needed for factories, hotels, &c., but not for private houses.....78 to 80
9th. Others object that revenue cannot be collected in advance..... 80
10th. It is said metres for every house would cost a vast sum..... 81

WHY WATER METRES HAVE NOT BEEN GENERALLY ADOPTED..... 84

DIFFICULTIES IN THE WAY OF CONSTRUCTING A RELIABLE WATER METRE..... 85

1st. The sediment and other impurities in the water..... 85
2d. The difficulty of rendering metres sufficiently durable..... 86
3d. The difficulty of securing sufficient accuracy of measurement..... 87
4th. The difficulty of making metres sufficiently simple and compact, 87
5th. The difficulty of constructing metres so as not to obstruct the flow or head of water..... 87
6th. The difficulty of rendering metres sufficiently inexpensive for general use..... 88

Frank G. Johnson's

TURBINE COMBINATION WATER METRE.

Patented January 1, 1861.

ITS DESCRIPTION, OPERATION, DURABILITY, &c.....90 to 102

RELATIVE IMPORTANCE OF DIFFERENT MERITS IN WATER METRES..... 102

THIS METRE ADAPTED TO OTHER PURPOSES..... 104

THE

ACTUAL MEASUREMENT SYSTEM

OF

CHARGING FOR PUBLIC WATER.

MAGNITUDE OF THE GENERAL SUBJECT.

THERE are over a hundred cities in the United States and the Canadas alone, supplied with public water works, at an aggregate cost of about *one hundred millions of dollars*, supplying one of the most indispensable elements of life and happiness to, at least, *five millions of people*, and as many animals—favorably affecting everything connected with eating, drinking, and cleanliness, as well as protecting us from the dangers of stench, disease, and fire, and constituting, also, one of the mightiest labor-saving institutions of the age.

Yet the great work of supplying cities and villages with public water is only just begun—most of the present works having been built within a very few years—while not one place in a hundred, which soon will have these important improvements in full operation, has yet commenced to agitate the subject.

The magnitude and importance of such works being so great, why not bring to bear, upon the use and distribution of the benefits which it is intended they shall afford, the ordinary principles of equity and economy, in order that, while no person shall be overcharged for what he receives, others shall not be allowed to enjoy such comforts at the expense of their neighbors, as well as to cause every one to husband the great blessing, and thus cause this enormous outlay to go as far as possible in accomplishing the end for which it is expended.

REASONS WHY WATER METRES SHOULD BE ADOPTED.

1st. They are in keeping with the principles which govern all buying and selling.

Buying and selling are regulated by *kind*, *quality*, *quantity*, and *price*. As water, the article in question, is always the same, in kind and quality, only *price* and *quantity* are to be considered. Every commodity is bought and sold on the plan of fixed quantities and prices, from a row of pins to a drove of cattle—so much for so much—it being expected by every one that he may and shall receive *what and all he pays* for; and it is demanded, also, by all, that every one shall *pay for what and all he receives*

This is the only equitable and satisfactory method by which buyers and sellers can conduct their exchanges. Money itself, for this purpose, is divided into fixed quan-

tities—cents, dimes, dollars, shillings, pence, &c., and we have also a *unit of measurement* for everything bought and sold—acres, yards, feet, pounds, ounces, bales, dozens, hundreds, hogsheads, barrels, gallons, bushels, &c. All *labor* is hired upon this principle: "A fair day's wages for a fair day's work." Transportation and traveling is so much per mile. Even our clergymen, legislators, and school-teachers are employed at so much a year, so much a day, so much a quarter. Illuminating gas, for instance, going, in every respect, side by side with public water, is bought, sold, and paid for on this principle. The universality of this method—so much for so much—is almost without an exception, save in the distribution of public water. But, water, when it is brought to the consumer through artificial and expensive channels, has a commercial value, equal to its cost, and, therefore, the method of buying and selling it should not be made an exception to the general rule.

2d. Reason why Water Metres should be used is, to prevent waste.

Though public water works, in this country, are yet in their infancy, still the various Boards of Commissioners of these works have come to see the imminent necessity of preventing the enormous and profligate *waste* of water: for the reason that the maximum supply, in some cases, *is all consumed*, while in other cases it has already become necessary to *extend the works*, at an immense expense. *The wasting of public water must be checked, for the reason, also, that it is found to be greatly on the increase;* the proportion now wasted having reached undoubtedly to *fifty or sixty* per cent. of the whole amount. This is just what might have been anticipated, when we consider

human nature, and the various present methods of charging for water; for, it is the tendency of mankind *to save or themselves* and *waste for others.* Every restraint being removed and no inducements held out to practice the least economy, unbounded wastefulness is the inevitable result, which, if not checked, must eventually exhaust the most abundant supply.

It is the height of absurdity to suppose for a moment that full one-half, or more, of the public water *would not* be wasted; when it is considered that, being pent up against the almost irresistible force of its "head," it is next to impossible to confine and hold it back; and especially when we consider, too, that (so to speak) this one hundred millions of dollars' worth of sparkling and lively element has, at least, *four or five millions* of escapes or faucets, great and small, in public and secret places, almost continually pouring forth their great and little floods at the option of *five millions* of people, without a solitary self-interested guardian to watch and timely close one of these ever-opening doors of escape.

In corroboration of these general statements about the waste of water, here are some of the evidences, taken from a few of the annual reports of different Water Boards.

John H. Rhodes, Purveyor Nassau Water Works, Brooklyn, N. Y.—than whom few men have presented more just and sensible considerations on the subject of water rates—in presenting his views at length, under the direction of the Board of Water Commissioners of the Nassau Water Department, says:

"I will endeavor to show from statistics that no system can be considered permanent and reliable that is not based upon the plan of measuring the water to each consumer. Facts teach plainly that the disposition to waste water will certainly

increase faster than means can be provided for increased supply, and that, consequently, every city must ultimately reach a point of inefficiency, unless such a system of measurement is adopted.

'To illustrate this tendency, the experience of other cities, taken from the annual reports of their Water Boards, may be cited.

"In London, where the water has been distributed by measurement to each house, the report of the general Board of Health, 1849, states the average supply to each person as less than 30 gallons per day. Formerly, this quantity was considered a proper basis for a calculation of supply, as being the maximum required.

"The report of the Jersey City Water Works, July 1st, 1858, states that the average for the whole year amounts to nearly 60 gallons for each individual. This is a quantity entirely beyond the wants of such a population, and indicates an enormous waste, which can only be checked by a strict watchfulness, and the enforcement of the most stringent rules.

"The complete perversion of reasonable anticipation is fully shown in the case of the city of Boston. Their works are very recent, having been finished in 1848, and considered as embodying the best teachings of experience and science. In the plan of the works, 30 gallons per day for each individual was considered a liberal supply. At the end of ten years, allowing for an increased population of 175,000, 5,250,000 gallons would be required daily, and, at the end of twenty years, 7,500,000 gallons. Now contrast the practical results. The anticipated demand at the end of ten years was exceeded at the end of two, and the actual quantity used, at the end of ten *years*, was 5,000,000 gallons per day *more* than was supposed would be required at the end of twenty *years*. The estimate of the increase of population has proved to be accurate.

"In reference to the use of water in the city of Brooklyn during the six months ending July 1st, 1860, I find that there

had been inserted 9,640 taps for domestic purposes. Allowing the very lowest estimate of eight occupants per house, we have 75,680 persons ; allowing them the minimum quantity per day of twenty gallons each, we have a consumption of 2,270,400 gallons per day.

"By a careful estimate of the quantity of water drawn from the reservoir, I found the consumption for domestic purposes to have been at the rate of 2,299,726 gallons per day ; exceeding the estimate of 30 gallons per day, as above, only by 29,326 gallons. It must be borne in mind, however, that this is an estimate for six months' consumption, and that, previous to the first of March, but about 6,000 taps had been inserted, as against the whole number, 9,460, on the 1st of July, upon which latter number the average consumption is based. I make this statement in order to show the large amount of water consumed at a time when there was no convenient means of disposing of the waste water by means of sewers. When, however, the city shall have completed the sewer works, and the means at hand to run off the waste water are fully commensurate to the ability of the water works to supply, the inevitable result will follow, viz. : an enlargement of the works, in the vain hope of keeping up with the demand.

"By permitting the unrestrained use of the water, it cannot reasonably be expected that a less quantity than 75 gallons per day will be consumed by each person as a basis of average, even when the interests of the city are guarded by a vigorous watchfulness and rigid enforcement of the rules and regulations of the Water Department. But the real wants of the citizens do not require such an expenditure, either as a necessity or luxury. A wanton or careless waste of water by one of our citizens must, by the present mode of taxation, fall upon his more careful neighbor."

Mr. Rhodes, after making numerous quotations from other Water Boards, says :

"It is needless to multiply quotations to prove the palpable fact of *excessive and constantly increasing waste.* The losses

resulting from this waste, are, some of them, common to all systems of supply, and some peculiar, as involving the direct expense of pumping the water. The most obvious of these are the great cost of the large mains required for distribution, and the inefficiency of the service in regard to the height of flow, force and quantity. *It is not too much to state that the size and cost of pipes for city water works, as well as of the reservoirs, could be reduced one-third, if the quantity to be furnished could be calculated without reference to the unknown quantity of waste.*

"I have thus endeavored to place before you a part of the great mass of testimony which goes, in my opinion, to prove the proposition that waste will increase faster than water can be provided, and that every city water works, not based upon the metre system, must sooner or later reach a point of inefficiency or failure. I have endeavored to controvert the dangerous and common error, that, so long as more water is at hand than is really needed, it may as well be wasted. I have quoted the concordant testimony of all the best authorities, that a cheap and reliable metre has been the great desideratum, and have expressed my conviction that great advance has been made by inventors towards it. Whether to such an extent as to warrant the belief that any radical change in the system of serving water will result, it is not for me to decide."

The Report of the Nassau Water Department, for 1860, says:

"In our last report to your honorable body, we showed that the daily average consumption of water per family, for the six months immediately preceding, was $243\frac{1}{10}$ gallons, which, at the time, was considered very extravagant, involving, as was supposed, a reckless disregard of economy in the use of water for domestic purposes; yet, when we come to compute the daily average use of water for the succeeding six months ending December 31, 1860, for the same purpose, we find that the sum has reached $316\frac{6}{10}$ gallons per family, and that, too, with-

out any apparent necessity for such increase. Feeling this to be true, *we are forced to the reluctant, if not alarming, conclusion, that an end to the profligate and wanton waste of water is not yet, and that, unless some means are adopted to restrain consumers in such recklessness, the daily consumption of water will continue to increase in proportion to the facilities afforded them for carrying the same from their premises.*

'The fact is thus made apparent, that, like all other Water Works, we are suffering from the constantly increasing waste of this valuable necessary of life. We find, after using the greatest possible diligence in endeavoring to protect the works from waste by passing stringent rules and regulations for the government of the water consumers, and appointing Inspectors whose duty it is to constantly guard the distribution of water and enforce the rules and regulations, that, notwithstanding all our efforts, we are constrained to admit that there is a large amount of water running to waste daily by carelessness or otherwise. This Board therefore have come to the conclusion that there is no way to overcome this difficulty and to effectually check the unnecessary waste, *except it be by a general use of the Water Metre, which will at once render the distribution of water just and equitable.* Hoping to meet the hearty co-operation of your honorable body, we shall, at an early day, make a special communication to you, giving the reasons and facts which have led this Board to come to this conclusion, together with such recommendations in reference to water rates as the circumstances would seem to require."

The Report of the Chicago Board of Water Commissioners, for 1861, says:

"If the consumption of water continues to increase in the same ratio for the year to come, it will be as much as we can do, at all times, to give a good and generous supply. This being the condition of things, it becomes necessary that we adopt measures to prevent the great waste of water, *by the use of metres* and other restrictions.

"The large amount of water used for sprinkling the streets, for cleaning the sewers, for fountains, and other purposes of luxury, all of which are increasing in a four-fold ratio, together with the immense increase in the amount which will be required for machinery and other mechanical purposes, demonstrate the necessity of preparing our minds, and the minds of our citizens generally, for the adoption of some important and permanent improvement in that direction."

The Report of the Trustees of the City Water Works of Cincinnati, O., for 1861, says:

"By reference to the Report of the Engineer, it will be seen that, during the past year, we have been compelled to furnish 16,964,624 gallons more water than the average of the two preceding years; and although the aggregate amount for the year has been less than the total for 1860, the first six months' consumption for 1861 largely exceeded the demand for the corresponding months of the preceding year.

"This condition of affairs, occurring during a season when the establishments of many of our largest manufacturing consumers have been either partially or wholly closed, is clearly attributable to leakage and waste, and demands your serious consideration."

The Annual Reports of the Croton Aqueduct Department, from time to time, contain the following:

Report of 1859: "The unnecessary and ever wonted waste of water during the whole year cannot have escaped observation. The necessity for a more rigid police and more stringent rules for regulating the use of water will be apparent, when it is stated that very nearly the whole volume of the Croton river has been delivered in the city during many weeks the past summer, a supply three times greater than any legitimate use of it would demand."

Report of 1850: "The most unremitting and zealous exertions of the department to abate the intolerable waste of water

have produced an effect scarcely perceptible to the public eye, and it frequently happens that the reservoir is drawn down to half its capacity, making an aggregate of 40,000,000 gallons for a single day's consumption, or ninety gallons to each individual. This Board now warns the Common Council, and through it every citizen, that the last drop of water, which the works in the present state can supply, is daily delivered in the city—a supply more than equal to the legitimate wants of a population of a million and a half. With some little regard to reasonable economy, the daily quantity is amply sufficient for all domestic and manufacturing purposes for a quarter of a century to come."

Report of 1851 : "Millions of gallons are worse than wasted in flooding instead of sprinkling streets ; to these add the hundreds of streams kept running in stores and warehouses throughout the year, and the catalogue would begin to show its enormity. To stay these accumulated abuses, the department is at all times exerting the influence it possesses, but without the aid and support of consumers themselves, its progress in so herculean a work must necessarily be slow and unsatisfactory.

"Whether such aid will ever be extended to it by an economical use of water, short of the suffering produced by a deficient supply, is not to be expected ; bad habits are already too thoroughly rooted, and privileges, for which a daily thanksgiving should be offered, are so commonly and so constantly abused as scarcely to find a rebuke in the best regulated families. Would these families tolerate a like waste in other and less necessary supplies ? If it were possible to circumscribe the use of water to indispensable purposes, only furnishing for these the most liberal supply, no addition would be required for the next twenty years, except to guard against accident to the aqueduct itself."

Report of 1853 : "So certain are the elements of calculation, that, if no systematic effort be made to circumscribe the use of water, *eight years will bring us to the daily consumption*

of all the capacity the aqueduct can bring, and more than twice as much as the minimum flow of the river can furnish. How different is this aspect of the subject from those presented in the early reports of the Water Commissioners, which, unfortunately, taught our citizens to believe that the supply would be equal to any possible demand for a period reaching far into the future, and thus unintentionally encouraging the lavish use, as well as unpardonable abuse, of the great privileges conferred by the work."

Report of 1854 : "The Board regret that they are compelled every year to allude to the unwarrantable waste of an element so valuable and indispensable to the health and comfort of their fellow-citizens. Notwithstanding every effort has been made to check the waste of water, *they have every reason to believe that the very great proportion of the water placed at the disposal of the consumer is used for no valuable or practical purpose.*"

Report of 1855 : "The waste of the water, in streets and buildings open to observation, has been repressed and greatly diminished for the present, but the improvement can be maintained only by an unflinching collection of the penalties from all delinquents. The probably much greater waste which results from the careless, profuse, and excessive use of the water in families, amounting to an enormous quantity actually wasted, cannot be reached, without invading a privacy which it is too delicate an exercise of the authority confided to the Board to attempt. The careful use and reasonable consumption of the water in families must, therefore, be left to the moral sense of those who govern domestic establishments, and in mercantile houses and business offices, to that class of men who are known to be influenced in their particular occupations by the dictates of right reason and equal justice. But, nevertheless, the Board feel that they are not absolved from the duty of exacting the penalties for waste whenever a a case of delinquency is discovered.

"Being of opinion that the application of metres to all buildings would repress the waste and increase the income of the water, the Board will be disposed gradually to introduce the system, under a suitable law, by way of experiment, so soon as a metre shall be produced which will be sufficient, and come at a price low enough to justify the payment for their cost."

Report of 1856: "We have not the water to spare. For the last twelve days there has not been a drop of water passed over the Croton dam. In nine days the water in Croton lake has fallen eleven inches. From this it is demonstrated that we are now bringing to the city daily upwards of 9,000,000 gallons more than the Croton river supplies! Already we have complaints from every part of the city that the water does not rise in different localities sufficiently high to supply consumers, and already the energies of this department are taxed to the utmost to keep up a sufficient head in the reservoir to preserve the city from fire, and to answer the legitimate demand of the inhabitants. It is indisputable that we have not a gallon of water for any other than its present use."

Report of 1858: "But very little can be added to the reports of former years on the subject of waste. No restraint in this regard seems to be exercised by householders, and no efforts on the part of the Board seem to be of any avail in checking a degree of waste within the doors of private houses and stores, which is as unwarrantable and dishonest in itself as it is unjust to the officers whose duties and cares it renders doubly harassing. The waste outside of buildings has been, in some degree, diminished by prompt enforcement of penalties, but within the houses the inhabitants must be almost wholly left to their own sense of right, and the Board have found that but little can be hoped for from the existence of such a principle."

The report of the "Cochituate" Water Board, Boston, Mass., for the year 1857, says:

"The unnecessary waste of water is an annual topic of

remark. The daily consumption last year was 12,726,000 gallons against 12,048,600 in 1856 ; an increase of about two-thirds of a million gallons daily. The increase of water takers was but 796 upon the gross number of 20,806. The daily consumption for each individual being 73 gallons ; it seems, therefore, that the last year strengthens and confirms the uniform rule *that the waste of water is, and has ever been, on the increase.* Now, what shall be done? This Board is far from wishing to sound any false alarm, but it requires no gift of foresight to make it certain that the present supply will be exhausted soon, at the present rate. Were the same causes in operation now that were one year ago, it is believed that the city would have a short supply on the high service, and that it would be impossible to keep the water in the reservoirs at a suitable height for safety in case of fire, and, in the nature of things, it seems impossible that suffering and danger will soon be upon us if some additional remedy be not found and applied. The constant daily draft made upon the supply has been too exhausting to allow of the playing of the public fountains, except on a few public days. The alternative is imposed of giving up these enjoyments or imposing a scarcity upon some parts of the city."

Other reports of this Board show that the average daily consumption has uniformly increased from *forty-one* to *eighty gallons* per day for each individual

Their Report for 1858 says :

"The original design was, to keep the water running in the brick conduit, at a depth not exceeding four feet four inches (or about two-thirds full). Whereas, it has been running with a head varying from four inches to two feet eight inches."

The Report for 1861, alluding to a certain connection that would cost $14,000, says:

"With this addition to the source of supply, there ought to be water enough for this city without any additional expense,

and the Board are confident there would be, were it not for the wasteful use of the water in the city

"This has been a topic of discussion in the various Water Reports for several years. The present Board have adopted energetic measures, by the aid of the police, for preventing this evil, and these measures have been attended with marked success.

"At the same time, the only efficient remedy must be found in the general adoption, throughout the city, of Water Metres, and an entire change in the assessment and collection of water rates."

The Water Report of Cleveland, Ohio, for 1861, alluding to Appendix D, says:

"This shows that the increase in the consumption of water from the water works has been in the following ratio, to wit:

In 1858 over 1857, $11\frac{3}{4}$ per cent
In 1859 over 1858, 30 per cent
In 1860 over 1859, $31\frac{1}{4}$ per cent
In 1861 over 1860, $23\frac{3}{4}$ per cent.

"The appended table shows also a very large allowance for each consumer; half that quantity would indicate a liberal consumption of water.

"*Undoubtedly there is every year an equal quantity of water wasted, as is used for all needful purposes.* This waste arises partly from leakage under ground by worn-out hydrants, which cannot very easily be detached in our sandy soil, and partly from hydrants wantonly left open and the water permitted to run.

"The employés of the works are particularly charged to be watchful about such waste, but having only two men who have other duties to perform besides, they cannot detect all the violations of the rules and regulations for the protection of the works. It is earnestly recommended to all water takers to use freely all the water they require, but to allow no waste, as every gallon of water is elevated to the reservoir

at the expense of the works, and the water needlessly wasted is a direct loss to the works and the *citizens in general.*"

The fourth Annual Report of the Board of Water Commissioners of Hartford, Ct., says:

"That the quantity of water consumed during the year (1858) has equaled the large total of 190,403,000 gallons. This amount is vastly more than it ought to be, and disclosed the fact of an enormous waste of water."

Thus we might go on indefinitely with such quotations from Water Boards of all cities and nations, which conclusively shows that nothing short of the *measurement system* will prove effective in preventing this enormous waste, which has come to be the greatest hindrance and drawback to the successful operation and introduction of public water works.

Some of the leading methods by which water is wasted, and illustrations given to show the amount of waste.

Though public water is freely wasted everywhere, at all times, and by everybody, yet there are general causes or methods of waste which should receive special attention, and which metres would prevent.

1st. *By the general method of plumbing.*—Pipes for *hot* and *cold* water, to save a little plumbing expense, are invariably placed side by side, which makes it necessary, every time a cup of cold water is needed, to draw off two or three pails full for the sewer.

2d. *By allowing the water to flow, to prevent its freezing in the pipes.*—This is a general practice, and constitutes an

enormous waste, as will be seen by the illustrations below; yet this practice is both unjust and unnecessary. After the city has spent millions of dollars to bring a "living spring" of water into every house, the recipients of this invaluable blessing do not lift a finger to protect it from frost, but tax their neighbors and the blessing itself for this purpose. Many a house wastes, for this purpose, as much water in four nights as is allowed that house, by general estimate, for a whole year. This can be stopped only by general use of metres. Under this head, the Report of Hartford, Ct., for 1861, says:

"The Commissioners desire to call especial attention to certain results which the foregoing table discloses. It will be seen that the average daily consumption the past year has been 1,098,850 gallons, and that the minimum daily average was 882,807 gallons during the month of April, and the maximum was 1,292,056 during the month of February, the difference between these two extremes being 409,249 gallons daily, or nearly 50 per cent. Now, when it is remembered that this greater quantity is used at a season of the year when no water is used for public or private fountains, street or garden sprinkling, and a greatly reduced quantity for building purposes, carriage-washing, and other similar demands, the disparity becomes still more remarkable, and can only be accounted for by assuming a general waste from pipes left running, to guard against the effect of frost. In fact, the difference between these periods, for all legitimate uses of the water, should be strongly the other way. The water discharged by a common service faucet, left open and running at the lower portions of the city, is equal to 10,771* gallons daily, and a very little arithmetic shows that 100 such faucets left constantly open would exhaust the whole amount required to supply the city, at the present rate of consumption.

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* By actual measurement.

The Croton Report for 1860, alluding to the order given to shut off the water at Croton Dam 4th of December, to inspect the Aqueduct, says :

"At the time the order was given, the water in the Receiving Reservoir was already twenty inches below the top waterline, and in the Distributing Reservoir it was proportionably lower than the usual height at that point. From close observation and experiments made during the fortnight previous to the 4th December, it became evident that the usual (though dishonest) habit of letting water run waste in dwelling-houses and stores, to prevent its freezing, had already been commenced for the winter, and that it was impossible, with such a drain through the outlet pipes, to fill the Receiving Reservoir to the height deemed necessary before the examination could be entered upon with safety. During this time the thermometer was not down to freezing point, and even the usual inadequate excuse for this criminal waste was wanting. It was very evident that, should the weather become suddenly colder during the time set for the repairs, the waste from this cause would be increased, and equally evident, from past experience, that should this waste be added to the usual consumption, during the time the gates were closed, the city would be without water before the examination and repairs could be finished. * * * * At the latest possible hour for a decision, it became evident that it was impossible to increase the store in the Reservoir."

How great, then, must be the waste from this cause. If metres were in use, householders would find a more economical way of keeping frost out of their cellars.

3d. *Another leading source of waste is, Water-closets and Urinals.*—Though it is intended that water shall be afforded at such cheap rates that places like these may not lack an abundance for all cleanly and wholesome purposes, yet it is absurd to suppose there can be allowed a

small river to flow constantly through them, or that, for practical purposes, such a flow is at all needed. It is not an uncommon occurrence for a single family to waste water enough in this way to supply a whole neighborhood for this and all other purposes.

"At a private house in Jersey City, where a metre was applied, it was found that 9,000 gallons were discharged during the first 24 hours. On inspection, this was accounted for by ascertaining that the water was allowed to flow through the water-closet constantly. The yearly allowance for which such a house is taxed is only 25,000 gallons. Hence, it is demonstrated that this house was consuming its year's allowance in every *sixty-seven hours—less than three days*—and during the year 3,285,000 gallons—something less than *two days'* supply for the whole city, the daily average consumption of the *whole city* being 2,000,000 gallons.

"This shows that 222 such closets would consume the entire city's supply of 2,000,000 gallons. Here is *one water-closet* recklessly wasting as much water as is allowed or allotted to *one hundred and thirty-one families*—all for the sum of *seven dollars and fifty cents* per annum.

"If this waste was paid for at the rates charged ($7.50 per 25,000 gallons), it would amount to $1,082.50 per year. (This case was related to the writer by the President of the Board.")

The Boston Report, for 1861, says:

"The Board are satisfied that some methods of using the water, heretefore allowed, are highly objectionable, and should be changed at once. One of these is the use of hopper water-closets. In order to test this manner of using the water, a metre was attached to a pipe that supplied five hopper water-closets at the Boston and Maine Railroad station, and in twenty-two days the metre indicated 543,187 gallons as the quantity consumed, or 24,690 gallons per day, which, at the tariff rate of two cents for each one hundred gallons per day for three hundred and sixty-five days, would amount to

$1,802.37. The amount actually charged in the tariff now adopted for five hopper closets, in 1861, was $25 !

"The Board have not hesitated to adopt a rule that no more water shall be supplied to hopper closets made on and after January 1, 1862."

Yet there are, at this date, 6,373 of these closets, which, it appears, are to continue to be supplied. The same report says :

"The metre that supplied nine water-closets and six sinks, in a factory (Messrs. Grover & Baker) indicated, in thirty-five days, 698,565 gallons to have been used, or 19,959 gallons per day, which, at the tariff rate of two cents for each one hundred gallons for one year, amounts to $1,197.36. The amount actually paid for these closets and sinks, for the year 1861, was $80 !"

If such results as these are brought to light by here and there a metre, what must be the aggregate waste in 11,460 water-closets and 1,383 urinals, which is the number of these places in the city of Boston.

The Detroit Report, for 1861, says.

"A five-eighths of an inch stream of water was found running steadily into a water-closet, which was situated in a dwelling over a store. On inquiry, the occupant stated that it had been running all summer, and that it had been allowed to do so by direction of the owner of the premises. A five-eighths pipe, under an ordinary head, will discharge about 300 gallons of water per hour, or 7,200 gallons per day, and more than 2,000 barrels in three months, for which the party paid *seventy-five cents.*"

At the estimate of 25,000 gallons per year, this waste, in one closet, would supply *one hundred and nineteen families* for all purposes.

The same report gives the following:

"Another instance of this careless indifference and wanton waste came to light the past season, accidentally, by the falling in of a sewer. Where a building had been removed, about four years ago, the hydrant was taken up without first shutting off the water, and a five-eighths of an inch stream of water had been running to waste into a sewer, discharging, during the time, about 10,000,000 gallons—equal to four days' consumption of the entire city."

Such cases as these, from the Boston, Jersey City, and Detroit reports, are not exceptions—there are thousands of them in every city.

It is probable—yes, positively certain—that *not one* such case would occur if the water were received through metres.

4th. *Steamboats are a source of immense waste.*—It is a practice to cool down boilers by letting out *hot* water and letting in *cold* at the same time, in order to cool down gradually, for the benefit of the boiler. It is doubtful if this practice would continue under the influence of metres—if it should, the water would be *paid* for, and, too, by those who use it.

5th. *Rivers of water are wasted in sprinkling streets and yards and washing windows and houses.*—It is right that water should be used for these purposes, but not uselessly wasted. If householders had water metres standing in their cellars by the side of the gas metres, they would find it for their interest to turn off the water as soon as the dust is fairly laid, as *now* they do to turn off the gas when they go to bed, or at least when the *sun rises*.

6th. *Builders waste a large amount of water.*—If water for building purposes should be rated by the gallon, instead of by the number of bricks used in building the structure, the builder would find it convenient to instruct his employés

to turn *off* the water instead of turning it into the *sewer* every time they laid down the hose pipe, to be gone two or three hours at other labor.

7th. *All kinds of stables are a source of great waste.*—The force of head of public water renders it exceedingly convenient and useful in washing carriages (that is, with the hose pipe); but it having been, in its employment for this purpose, so abusively and wantonly wasted, there has been in many cities a total prohibition put upon this most convenient use of it.

While proprietors of stables can afford to pay the *regular rates* per gallon for all the water really *needed* for this purpose, yet they are deprived of it altogether, as a protection against their careless and reckless waste of it, when allowed to use it at all in this manner. Metres would render the public water available for this purpose, without too greatly exhausting the supply.

8th. *Manufactories, Breweries, &c., waste floods of water.*—Though many of these establishments pay large sums for water, yet this creates no inducement to practice economy and prudence in the use of it. The contrary, rather, is true. These concerns, having the facilities to do so, *waste oceans* of water. Were they to pay by the gallon, their large openings would be guarded with the utmost watchfulness, for as their capacity to *waste* is immense, so also would be their inducement to practice care and frugality.

9th. *Waste for amusement.*—There are many cases where water is allowed to discharge from hose pipes for hours together, to gratify children. This would not be tolerated nor allowed any more with water than with gas, provided, as it is with gas, a metre in the cellar was effectually ad-

monishing them of the folly, wickedness, injustice, and, above all, the *personal* cost of the practice.

10th. *Public Water, in some instances, is even used for Motive Power.*—Perhaps the number of these cases does not warrant a mention of them ; but they are not alluded to so much because of their frequency as to show how *grossly* persons will *pervert* and *abuse* the use of public water—which many, in fact, *most* people, feel unrestrained from doing, because they know they are not paying on the principle of *so much for so much*, and because they erroneously think they are not—as, in fact, they really are—doing *themselves* an injury, as one of the common supporters of the public works.

The Probable Percentage and Increase of Waste.

Although, of the whole amount of water brought to the city, it is impossible to determine the exact proportion wasted, yet, by noting the very great disparity in the number of gallons used per individual in different cities, and the great increase of quantity per each person from year to year in the same city, we are legitimately forced to the alarming conclusion, that *the consumption of water is doubled every few years*—notwithstanding full allowance be made for manufactories and increase of population.

Hence, as individuals and families, for all practical purposes, need no more water *this* year than they did five or ten years ago, this increase of the domestic consumption must be *entirely* attributable to the fact, that the people

are rapidly increasing the dangerous habit of wantonly wasting the water.

The average individual consumption of gas and food, for instance, is no greater now than it was five or ten years ago—nor would it be of water, if, like these commodities, it were bought and sold per measurement.

To illustrate still further this enormous increase of waste, we give the following table, which exhibits the average daily consumption, in different cities, for each inhabitant, each consumer, and each taker:

CITIES.	YEAR.	AVERAGE NUMBER OF GALLONS PER DAY.			Proportion of inhabitants using Public Water.
		To each inhabitant.	To each individual consumer.	To each taker.	
Detroit	1861	41	52	271	78 per ct.
Cleveland	1861	16	114	814	16½ "
Louisville	1861	9	74	606	12½ "
Buffalo	1861	63	222	1775	28 "
Brooklyn	1861	17	56	448	30½ "
Cincinnati	1861	24	51	405	48 "
Hartford	1861	34	34	277	100 "
Boston	1861	100	112	714	90 "
Baltimore	1861	23	44	353	53 "
New York	1861	37	67	533	56 "
Average for the ten cities		36	82	620	51 per ct.

In London (Eng.), where the water has been distributed by measurement to each house (which is accomplished by allowing the water to flow but a given number of minutes each day), the report of the General Board of Health, 1849, states the average supply to each person as *less* than 30 gallons per day. Formerly, this quantity was considered a proper basis for calculation of supply, as being the *maximum* required.

Yet the average of these ten cities shows that 36 gallons per each inhabitant are consumed, while only *fifty per cent.* of the population are consumers; and 82 gallons per each actual consumer—being nearly *three times* the supposed maximum quantity needed. Hence it is safe to conclude *that three-fifths of the water is wasted.*

Again, to compare cities: Buffalo consumers use *five times* as much water as those of Baltimore; and Cleveland and Boston nearly *three times* as much. There is no real foundation for this great discrepancy. These families do not so widely differ in their consumption of any other article—why should they in their use of water? It is to be accounted for only by *waste.* No such inequality would exist under the measurement system.

Allowing 25,000 gallons per year for a dwelling-house taker—this being about the basis upon which the rates are established—and estimating seven persons to a family, each person's daily allowance would be *nine* gallons. Now, by allowing that one-half of this general average of 82 gallons per consumer (of these ten cities) is used for fires and manufacturing, it still leaves 41 gallons per consumer for domestic purposes, which is nearer *five than four times as much as is allowed* for such purposes. Hence it is evident, again, that *at least three-fifths, or 60 per cent. of the water, is wasted.*

The Superintendent of the Buffalo Water Works says:

"I estimate the waste from *fifty to seventy-five per cent.*"

The Cleveland Report for 1861 says:

"Undoubtedly, there is every year an *equal* quantity of water *wasted,* as is *used* for all needful purposes."

The Croton Board, in Report of 1854, says.

"Notwithstanding every effort has been made to check the

waste of water, they have every reason to believe that *the very great proportion* of the water placed at the disposal of the consumer is used for *no valuable* or practical purpose."

Another evidence that at least 60 per cent. is wasted, is in the fact, that the average actual cost of water, in six of the principal cities, is only eight mills per one hundred gallons, while the average charges, intended only to cover costs, are thirty-two mills per one hundred gallons; being nearly *four* times greater than the actual cost. This great difference in cost and rates is owing to the fact that the greater part of the water is wasted, for which the city receives no pay at all.

The present Method of Preventing Waste.

The following are some of the stringent rules and regulations by which it is attempted to prevent waste; but it is apparent that, while they tend to diminish the revenue by preventing, in some cases, the useful consumption of water, they do but little to accomplish the object intended:

"The use of street-washers or hand-hose shall be restricted to one hour before 8 o'clock in the forenoon for the whole year; from the first of March to the first of September, to one hour before 6 o'clock in the afternoon; and from the first of September to the first of March, to one hour before 4 o'clock in the afternoon, and at no subsequent hour of the day or evening, under a penalty of Five Dollars for each offense; and if found out of order, cap off, or leaking, or if converted into jets, or suffered to run when not used, the supply will be cut off without previous notice.

"No hose will be allowed for washing carriages or vehicles of any kind.

"No owner or tenant of any premises supplied with water by the Company will be allowed to supply water to other persons or families; if found so doing, the supply will be stopped, and the amount of payment forfeited.

"No addition or alteration whatever in or about any conduit, pipe, or water-cock, shall be made, or caused to be made, by persons taking the water,

without notice thereof being previously given, and permission had in writing from the Secretary.

"Every man who has a branch of the Aqueduct, and shall refuse or neglect strictly to comply with the rules established by the company, shall be deprived of the use of it; and the agent of the corporation is hereby required to give notice to every individual who takes the water, that the branch of any one, who shall waste or give away the water, or allow the drawing place to be left so exposed as that his neighbors may come and take it, shall immediately be cut off; and that every person, whose drawing place is not in his dwelling-house or out-house, shall, within fifteen days, inclose it in a box, the door of which shall be locked, so that no person shall draw water but for the use of the families that pay for it.

"All persons taking the water shall keep their own service-pipes, stop-cocks, and other apparatus in good repair at their own expense, *and shall prevent all unnecessary waste of water*.

"In case of fraudulent misrepresentation on the part of the applicant for the use of water not embraced in the application for the same, or for willful or unnecessary waste, the water will be immediately shut off, and payment forfeited.

"No hydrant will be permitted on the sidewalk or in the front area, and if standing in a yard or alley attached to any dwelling or other building, will not be permitted to be kept running when not in actual use. Taps at wash-basins, water-closets, baths, or urinals, must be kept closed in like manner.

"When cisterns are so located as to supply separate premises, and may be filled from a hydrant, water rent must be paid for all families or other consumers having access to said cistern.

"Cisterns located on premises where there is no hydrant, must not be filled from the hydrant in any case.

"Hydrants must not be located so as to be exposed to use by non-paying consumers, and all hydrants so situated must be removed to some secure location on notice, or the water turned off.

"The following abuses are absolutely prohibited, to wit: 1st. Permitting or allowing the water to be used for any other purpose than those named in the bill. 2d. Sprinkling gardens, streets, or sidewalks, or washing carriages, omnibuses, cars, or other vehicles with hose, without a special permit obtained and paid for at the office; and in no case will hose be allowed for the above uses with out-flows or nozzles, when used for washing carriages and other vehicles, greater than one-eighth of an inch, and for any other purpose greater than one-quarter of an inch diameter of circular opening, or their equivalents. 3d. Permitting leaks. 4th. Allowing water to flow unnecessarily while washing pavements and for similar purposes.

"Refusal or neglect to conform to the above rules and regulations subjects

the parties to have the water turned off—to the forfeiture of the water rent —the payment of penalties varying from fifty cents to five dollars—and to prosecution and fine in the Police Court."

Suppose a joint stock company to undertake to furnish illuminating gas to its consumers for a fixed price per year, and depend upon such regulations as these to insure an economical use of it. Again: suppose the company should occasionally distribute a little moral advice on the subject of general wastefulness, to prevent the takers from using more gas than they pay for, or more than their share of the aggregate quantity paid for by all; and, to learn if any were doing so, and *if* they *were*, to prevent them, suppose a special police to be appointed to go about noting the time of lighting and turning off gas, and the number of rooms in which it is employed for lighting, cooking, heating, &c., and the number of burners used; with a view of telling the more extravagant takers that they must be more economical in future. Without metres, and depending upon such protections as these, no private gas company could survive a year. Yet, as *light* cannot be hid, except it be "put under a bushel," there is less chance of wantonly wasting *gas* than *water*.

A general use of Metres would make every Taker an interested and self-appointed Guardian of the Works; being the only method by which the waste can be prevented.

The present method of fixing water rates are in total violation of the principles of economy, and tend to cultivate the habit of general wastefulness. Consumers now seem to think the more water they can run through their

faucets the more nearly they "get their money's worth;" forgetting, because they are not at once reminded of their extravagance, and made to pay for it as they go, that ultimately they must, in common with all, pay for the whole. With metres in their houses they would at once learn that water *costs* something per gallon, and that it is *worth* something per gallon, by being obliged to pay a *fixed price per gallon for it*. It is next to useless to appoint agents to look after the waste of water, or to pass stringent rules and regulations on the subject. To successfully prevent the waste of water, the same influence must be brought to bear which, and *only* which, prevents wastefulness of all other commodities, *and that is pecuniary influence—self-interest*. The *supply* of water is in the hands of the city; but as the consumption of it—use and abuse—is *wholly* in the hands of the *takers*, they *alone* can prevent the waste. But to reach the takers their pockets must be touched. This can be done *only* by the use of metres. The Department cannot reach the *taker* in any other way, much less the *children* and *servants* of the taker, but the taker himself being reached, *he* will see that his family and employees do not violate the principles of economy at his expense by wantonly or carelessly wasting the water—if he does *not*, why, let him *pay the bill*, and the *Department*, his *neighbors*, and *justice* will all be satisfied.

The metre would appoint, without trouble, cost, or attention of the Department, about sixty thousand interested *taker-agents* in New York alone; and these would appoint, and see that they did their duty, at least six or seven times as many more *consumer-agents* to act under them, every one of which would either do something to prevent the waste of water, or be compelled to pay accordingly.

Extracts from Water Reports to show that it is the opinion of Water Boards, generally, that Metres are the only remedy against waste and injustice.

The Boston Report for 1861, speaking of the means of preventing waste, says:

"At the same time, the ONLY efficient remedy must be found in the *general adoption*, throughout the city, of water metres, and an entire change in the assessment and collection of water rates."

The New York Report of 1855 says:

"*No satisfactory* estimate of the consumption of water at some of the manufactories and hotels can be made without the intervention of a *water metre*.

"Metres have been placed on sixty-eight large buildings, and have operated beneficially in determining the quantity of water consumed, and the Board propose to extend the system in special cases of hotels, factories, &c., as circumstances may require."

The same Report for 1854 says:

"As stated in the last annual report, water metres have increased in favor, and the consumer who could not be convinced of the quantity of water used in his establishment, has now a *certain and impartial umpire*, and though the result in almost every case is against the consumer, yet the decision of this small, but very costly, apparatus is generally acquiesced in. The only objection to their far more extensive use is the expense of the apparatus, and some loss in the head of water to those who require its use at high elevations; and it is to be hoped that the ingenuity of some practical inventor may yet overcome these difficulties, and render their adoption more extensive."

The same Report of 1858 says:

"The waste outside of buildings has been, in some degree, diminished by prompt enforcement of penalties, but within the houses the inhabitants must be almost wholly *left to their own sense of right, and the Board have found that but little can be hoped for from the existence of such a principle.*"

The same Report of 1850 says:

"The most unremitting and zealous exertions of the Department to abate the intolerable waste of water have produced an effect *scarcely perceptible* to the public eye."

The Chicago Report for 1861 says:

"This being the condition of things, it becomes necessary that we adopt measures to prevent the great waste *by the use of metres*, and other restrictions.

"It is our own experience, as of Boston, New York, and other cities, that metres afford the ONLY just means of assessing parties using large quantities."

The Brooklyn Report, says:

"The sale of water by measurement (metres), then, if feasible, we say, is the ONLY *equitable and just* mode of disposing of it.

"This Board, therefore, have come to the conclusion, that there is NO WAY to overcome this difficulty, and to effectually check the unnecessary waste, *except it be by a general use of the water metre, which will at once render the distribution of water just and equitable.*"

The Cincinnati Report for 1861 says:

"The ONLY true mode of arriving at a correct assessment is by an *universal application of a reliable metre.*"

Mr. Rhodes, Purveyor of Brooklyn Water Works, says:

"*No system* can be considered permanent and reliable that is not based on the plan of *measuring the water* to each consumer."

Again he says :

" . . . . Every city water works, not based upon the *metre system*, must, sooner or later, reach a point of *inefficiency* or *failure*."

The Boston Report for 1861 says .

" . . . . The most *just, satisfactory, and equitable* method of charging for the water would be by *actual measurement*, so that each citizen may pay for just the quantity he uses."

" . . . . Where a measurement of water seemed indispensable, the Board have caused metres to be introduced."

The Detroit Report for 1861, alluding to the measurement system, says :

" Every one would then be charged for what they choose to use, or required to be delivered, and *no more*. This can be ascertained by requiring all consumers to affix *a metre* to their service-pipes, which would accurately register every gallon of water delivered, when payments could be made at a fixed rate per gallon."

The Cleveland Report for 1861 says :

" The *purchase of a few metres* is again solicited, chiefly for the purpose of ascertaining the quantity of water consumed in large establishments, where the water at present is used most lavishly."

The reason we have said so much about waste is, because *this* INCREASE *of waste is the alarming feature of the subject.* Public water works, and the nature of water itself, afford such extraordinary facilities for gratifying this tendency to wastefulness, that we may soon look for indications of failure to meet the demand, unless a remedy be applied, which *no man, at all conversant with the subject, doubts can be found in a suitable metre.*

The nature of gas, and its uses, are such that, relatively,

but a small quantity would be used or wasted even if it were supplied without metres, and its consumers were to use it for all heating and cooking purposes; but water—so mobile as it is—drawn by gravity, and irresistibly forced along by its head, unceasingly flies with the speed of lightning to its mother, the ocean or river; while, by steam and pump, the elevation of it again to its high leaping-place, the reservoir, is quite a different process—heavy, slow, and expensive. A *child* at the faucet can do what requires the power of a mighty engine to counteract.

3d Reason why Water Metres should be used is, to insure justice and satisfaction to all.

Of the many evils, which result from the enormous waste of water, the most prominent and extensive is that of *injustice* among the consumers. *Economy* and *equity* are equally outraged. The present methods merely *aim* at, but do not *reach*, equality. They come no nearer to meting out justice, than the police do to preventing the waste. On the supposition that all families use about the same amount of water, they are charged alike. Yet some families consume *a hundred and fifty times more than others.* Under the third source of waste, on page 24, it will be seen that one family was consuming—in a water-closet—as much water as is allowed for *a hundred and thirty-one families*, at a charge of $7.50 per year; and that another was using as much as is allowed for *one hundred and nineteen families*, at a charge of *three dollars per year.* Suppose a certain number of families should agree to buy and pay for provisions in common; and at the day of settlement it was found, by the grocer's books, that a Mr. Brown's family had actually taken flour, eggs, meat, potatoes, &c., sufficient to supply *one hundred and thirty-one families*, and at

a cost as many times greater than the amount of his share of the general payment, and how long would these families continue to pay for provisions on this basis? Yet, in point of equity, it is no less absurd to divide and pay the *cost of water*, than it is to divide the *expense of food*, on such a *false basis*. Again: suppose a block of ten houses were all supplied with gas through one metre, and the bill for gas to be equally divided between the ten families; why each of the ten neighbors would be walking up and down to see how *many* rooms were lighted, and how *long* they were lighted, &c., for fear that each would consume more than his equal share of gas; hence every taker *demands a gas metre of his own*, being *willing* to pay for all the gas he *consumes*, whether he burns it for lighting, cooking, heating, or any other purpose. People are not satisfied to divide *any* expenses in common, where it is possible to adopt the plan of each paying for *what*, and *only what*, each receives. The reason why the consumers submit to this unjust method of distributing water is, because the *injustice* of it is not generally appreciated, together with the fact that the Water Departments, heretofore, for the want of a suitable metre, have been *unable* to adopt any better and more equitable system.

The Methods now in use for fixing the Rates of Public Water.

These are various, and are made out upon quite different theories:

1st. *Upon the basis of the number of persons residing in a house*, the charges being, so much for each individual up to a given number; and then another rate per head for all over this number.

This method might do, so far as it goes, provided no person would use more water than were practically needed. But it does not reach the question of *waste*, for water will flow from a given faucet as freely with only *three* persons in a house as with a hundred. If a family consist of twenty-five persons, it does not take the whole twenty-five to turn the faucet. A single water closet, as will be seen, in a family of only two persons, may consume as much water as a hundred large families that make a reasonable use of water.

2d. *The basis of the number of rooms in a dwelling,* the charges being so much per room.

This method is self-evidently absurd; for, a dwelling of *twenty rooms* may contain only *three* persons, while twenty persons may live in a house of only *three rooms*. Hence, the management of the faucet has no necessary relation to the number of apartments in a dwelling.

3d. *The basis of the number of stories in a house, together with its width, depth, &c.*

This system is more absurd than the last—just as if water would not flow through a faucet as rapidly in a *high narrow* house as in a *low broad* one; in a *small*, as in a *large* dwelling.

4th. *The basis of the valuation of the property,* taken according to the city tax list, where water is taken.

This plan is still more absurd, for it does not even take into consideration either the *number of persons* or the *number of rooms*, and, much less, the *habits of the people*. Valuation of a dwelling depends upon its locality, magnitude, kind of material, style of finish, &c., which have not the remotest relation to the consumption and waste of water.

It may be that some, or all, of these methods have been adopted in view of *other* considerations than that of *charging for water per quantity consumed.* If *not*, there is no more correctness, equity, and satisfaction in any of these systems of regulating water-rates than there would be in adjusting them by the *color of the carpets* and *style of furniture* in a house. It would be no more absurd and ridiculous, even, as further on it will more fully appear, to judge of the speed of a horse by the length of his tail, or of the morals of a man by what he ate for breakfast.

5th. *The basis of the kind of business carried on in the building,* embracing everything under special rates, from a bath-tub to a first-class hotel, from a barber's shop to a navy-yard.

This plan is correct in theory; but, in practice, it is impossible to attain to more than loose generalities. It does not provide for the habits of the consumers; and it has to do more with the *relative* than the *absolute* amount of water consumed by the several branches of business. People, generally, are so different in their habits of using and wasting water, that a special rate is needed for almost every family. Even then there is no basis for calculating the *absolute* amount each would consume—metres would actually show a special rate for each house.

In the early introduction of public water, it was believed that the supplies would ever continue inexhaustible, and no metres were called for; and, when it became apparent that metres were needed, there were none, suitable, to be found; hence, the adoption and continuation of these unscientific, wasteful, and inequitable methods of distribution. But recently, it having become imminently necessary to economize the use of public water, many of the Water Departments have called for metres, and invited the atten-

tion of inventors to the subject. Some Water Boards have even held out inducements, by offering large premiums for the production of a suitable metre.

Quotations from Reports of Water Boards, in confirmation of the injustice of the present methods of distributing public water.

The Report of Salem, Mass., for 1860, says :

"The duties of the agent and collector are comparatively onerous and perplexing, and can be appreciated only by those who are conversant with them. The shifts and turns at deception in the use of water are manifold, and prove how sadly we have departed from the standard of truth, as demonstrated by Jennie Deans in the Heart of Mid-Lothian—but

> "When *self* the wavering balance shakes
> 'Tis rarely right adjusted."

As the agent has principally to rely upon the water takers, in one case, to render a true and accurate account of the number in a family, and in the other the quantity of water used, he has all sorts of people and all sorts of consciences to deal with, from the strictly honest and reliable, to those who appear preposterously to acknowledge no property in water, which is a gift in the providence of God, forgetting that the providence of God does not lay down pipes or convey water through them to their doors, and therefore believe it a venial offense to deceive in the use of it.

The Brooklyn Reports, at different times, contain the following :

"The city, not unlike an individual, has a commodity to dispose of, and if we adopt a system which shall approximate

nearest to the principle of exact weight or measure, then at least have we reached the equity of the cases under consideration, if no more. The equities of this subject involve perhaps, a greater diversity of opinion than any other policy of city government, and each individual of the community would imagine himself aggrieved when called upon to pay, under any such scale of rents that may be adopted, which falls short of actual measurement.

"In arranging the rent to be charged upon buildings we have suggested 18 different rates, without regard to the width of front under 50 feet. We have paid no regard to the value of houses of any description, for the reason—that there are such a great variety of values as to render such a proposition almost impossible; besides, the value of buildings cannot, under any circumstances, be a criterion as to the quantity of water consumed within them.

"So long as parties are allowed the indiscriminate use of water, there will always be a corresponding waste. There can be no doubt, therefore, but that the true policy would be to establish a rate, not upon the size of the building, but upon the gallon. Justice and equity would seem to dictate this course; yet, as no city on this continent has adopted such a principle, it would be difficult, indeed, to convince the public that such a plan would be advisable or ever feasible. We would suggest to your honorable body that, should it be deemed politic at any future time to change the present established rates, that the subject of furnishing water may be taken into consideration."

"In time for our next semi-annual report, we shall be in possession of sufficient data, we believe, to prove conclusively, to any unbiased mind, that the principle of rating dwellings, factories, and other structures, according to their dimensions and uses, is as fallacious as it would be to tax an individual to raise money for governmental purposes, according to his height in feet and inches, discarding entirely, in the consideration of the question, the amount of property in the possession of the person taxed."

"The sale of water by measurement, then, if feasible, we say, is the only equitable and just mode of disposing of it; and, if adopted by this city, we should be setting a commendable example to all other cities, whether of larger experience or not, and one, too, which, while it would not inflict a wrong on the greater, would materially lessen the burden now resting upon the more moderate consumer.

"The necessity of metres, for the protection of the interests of the city, is fully apparent. In most instances, where a difference of opinion has existed as to the quantity of water used by manufactories, the use of a metre has shown in almost every instance a consumption of from thirty to fifty per cent. more than represented by the consumer. The difference in some cases would pay the cost of a metre in three months.

"The above results show conclusively that the present system of rating dwellings by their dimensions, irrespective of the quantity of water consumed, to be extremely fallacious, and must result in a large annual deficit."

The Chicago Report for 1861 says:

The Board are introducing metres from time to time for the determination of the water rates of large consumers. *It is our own experience*, as of Boston, New York, and other cities, that *metres afford the only just means of assessing parties using large quantities.* Such parties have heretofore been assessed by an estimate of the amount used, and so long as there is no inducement for the consumer to limit his use of water to his real necessities, it is almost always found that the estimated amount is much too small. We have now some twelve metres, and have ordered others, with the intention of applying them to the large hotels, breweries, and manufacturing establishments.

"The rates determined by metres during the year 1861, amount to about four thousand dollars."

The Cincinnati Report for 1861 says.

"I am fully aware of the difficulty any one will experience

in correctly estimating the amount of water used in the almost infinite variety of manufacturing business carried on in our city, and I am far from claiming an infallibility for my own calculations. *The only true mode of arriving at a correct assessment, is by an universal application of reliable metres.*"

The same Report, alluding to waste, says:

"Any remedy that can be applied to abate the evil will redound both to the benefit of the works and the consumers, who seem to fail to comprehend that, in permitting unnecessary waste, they are robbing themselves, and that all the economy they may exercise will result in a proportionate saving of the amount they, as consumers, must pay for this indispensable necessary of life."

The Hartford Report for 1861 says.

"Many consumers manifest a strange indifference to the waste of water upon their premises, not apparently realizing that a moral wrong committed against the public is as heinous and indefensible as when committed against a private citizen; and what is regarded as a serious breach of good faith in the use and waste of water, by the commissioners, is too often regarded by the careless consumer, as a matter of too trifling importance for a moment's thought or care. Under our present limited means of supply, the commissioners feel impelled to appeal to the moral sense of a candid public, for a more serious and careful consideration of this subject."

The New York Report for 1855 says:

"No satisfactory estimate of the consumption of water at some of the manufactories and hotels can be made without the intervention of a water metre. The leading principle of the whole system, comprehending the price of the water and the collection of the rents, it would be difficult for the most experienced hands to improve, *unless a suitable metre can be furnished at a suitable price.*"

Mr. Rhodes says:

"A wanton or careless waste of water by one of our citizens must, by the present mode of taxation, fall upon his more careful neighbor."

Mr. Rhodes, again, while alluding to the cost of water, says:

"This statement of the cost of water testifies strongly of the *inability*, under the present system, to assess the expense *equitably*. It is no more nor less than a confession that *one* consumer must pay for the *waste of two or three others*."

The Boston Report for 1861 says:

"These results speak for themselves, and show that some radical change in this enormous disparity between the amount of water used, and paid for, is desirable; and it is quite certain that the most just, satisfactory, and equitable method of charging for the water would be by actual measurement, so that each citizen may pay for just the quantity he uses. Hence many are ready to advocate the immediate introduction of water meters over the whole city."

The Detroit Report for 1861 says:

"The rates charged are not for the Detroit *river water*, but for *conveying* it to the premises of consumers, and such service has a fixed, permanent, and unchangeable value, to wit: the cost per hundred gallons of delivering the same, and such rates are graduated by the Board to meet the requirements of the works to pay the annual interest and contingent expenses, and are meant to be as nearly according to the quantity consumed as possible. If the rates could be fixed exactly in proportion to the quantity of water delivered, no one would question the correctness of the principle any more than they would for being charged for conveying a certain number of cords of wood from the river to their premises."

"What is regarded as waste by those in charge of the works is regarded by the takers as a necessary use, or the waste at least trifling, but *water wasted is the same as taking its value in money out of the treasury.*"

"Some water takers manifest a strange indifference to the waste of water going on on their premises, and suffer leaks to continue indefinitely, if they can procure the requisite supply. Unmindful of the fact that a moral wrong is the same whether committed against the public or an individual, they do not seem to care at what cost to the public, in excess of the amount they pay, the supply is furnished."

The following results, brought to light by the measurement system, demonstrate the absence of all uniformity and the utter impossibility of correct conclusions without the use of *metres*.

The Boston Report, January 7, 1858, says:

"The subject of metres has engrossed a good share of attention during the past year. Some samples have been presented to the Board, which promised, or the owners promised for them, satisfactory results. So important is it deemed that a good and reliable metre of moderate cost shall be invented and brought into use in cases of large consumption, that the Board have authorized the purchase of 24 metres, for the purpose of giving them a fair trial."

The following is a part of the results of the trial, as shown by the report of 1859:

Schedule A.

Of the 60 metres purchased last year, twenty-three have been attached, and are now in operation at the following hotels, and show the average daily consumption of water; also the amount of the water rate charged to each, as compared with the amount received in 1858:

	Gallons per day.	Water Rate 1859, by Metre.	Water Rate 1858, by calculat'n.
Revere House	17,838	$1,116 85	$571 00
Parker House	14,557	897 80	240 00
Fremont House	14,142	846 50	475 00
American House	12,538	808 47	810 00
Marlboro Hotel	8 856	635 21	267 00
United States Hotel	8,854	678 80	672 00
Adams House	5,991	485 32	354 90
Coolidge House	5,681	426 56	281 00
Totals	84,857	$5,895 22	$3,670 00

Supposing one metre, of suitable construction, could be made to answer for each hotel, here is a saving—or an increase of revenue—in *one year* of $2,225.22 on *eight* metres; or $278.15 on *one* metre. See page 79.

The Purveyor of the Brooklyn Water Works, Mr. Rhodes, says:

"Our experience with metres has fully proved that the use of water varies so much in establishments of the same kind, or even in the same establishment on different days, that the constant presence of a metre is necessary for the determination of the quantity. No classification or average seems to reach the case at all. From my official records I extract the following variations:

One consumer varies from		1,197	gallons to	4,251	gallons	per day.
Do.	do.	871	do.	14,734	do.	do.
Do.	do.	15,438	do.	50,347	do.	do.
Do.	do.	10,436	do.	27,902	do.	do.
Do.	do.	4,979	do.	25,444	do.	do.
Do.	do.	4,987	do.	9,778	do.	do.
Do.	do.	1,016	do.	5,602	do.	do.
Do.	do.	461	do.	16,997	do.	do.
Do.	do.	22,446	do.	36,608	do.	do.
Do.	do.	15,165	do.	34,091	do.	do.

"These results were deduced from very careful and repeated observation of the metres, and are to me proof of the fallacy of any attempt at classification or general average.

"In a few instances, metres have been set at *private houses* as a means of ascertaining the average quantity of water used. The result has shown that the quantity of water used by different individuals, varies in a very extraordinary degree, ranging from *one hundred and thirty gallons to one thousand and seventy-five per day.*"

4th Reason why Water Metres should be used is, to render the Works more efficient.

1st. *By keeping a greater head in the Reservoirs.*—The waste being prevented, the reservoirs would be more constantly full, without either over-taxing, and thus endangering, the main conduit, or cutting short the necessary supply. The result of keeping the reservoirs *full*, instead of only *half full*, would be, in case of the Croton and other Works, to afford a supply in the two upper stories of a large part of the city, where *now* it is impossible to draw water, for want of sufficient head.

2d. *By increasing the* FORCE *of head in the* PIPES, and thus render the head more effective (or, rather, less ineffective), which will also aid in raising the water to higher elevations. The greater the number of openings, between the head in the reservoirs and a given outlet, the less will be the effective head at that given outlet; and *vice versa.* Hence, that the head may be as great as practicable, at any given place and time, it is desirable that no faucets, between this place and the reservoirs, be needlessly open.

3d. *By keeping a greater head and quantity of water constantly at hand, in case of fire.*—One of the greatest objects of public water works is, to afford more safety and protection against the powerful and merciless ravages of fire. Yet it is well known that, frequently, in case of fires, the head and quantity of water are so much diminished that the

works, in this respect, are rendered to a large degree ineffective.

4th. *By affording an abundant supply of water for public fountains, baths, &c.*—Many of the fountains, which have been built at great expense, have been entirely stopped and allowed to rust and go to decay, as nuisances in public places, for want of a supply of water to keep them in operation, while the needless waste of water in any half dozen water closets would keep a fountain in full play, as an ornament to the city, and a gratification to thousands.

In confirmation of the foregoing reasons why the Works would be rendered more effective, by preventing the waste of water, we subjoin the following testimony:

The Croton Report for 1856 says:

"Already we have complaints from every part of the city that the water does not rise in different localities sufficiently high to supply consumers, and already *the energies of this department are taxed to the utmost to keep up a sufficient head in the reservoir to preserve the city from fire*, and to answer the legitimate demand of the inhabitants. It is indisputable that we have not a gallon of water for any other than its present use."

The Report of the "Cochituate" Water Board, for 1857, says:

"Now, what shall be done? This Board is far from wishing to sound any false alarm, but it requires no gift of foresight to make it certain, that the present supply will be exhausted soon at the present rate. Were the same causes in operation now that were one year ago, it is believed that the city would have a short supply on the high service, and that it would be impossible to *keep the water in the reservoirs at a suitable height for safety in case of fire; and, in the nature of*

things, it seems impossible that suffering and danger will soon be upon us, if some additional remedy be not found and applied."

Mr. Rhodes, Purveyor of the Nassau Works, Brooklyn, says :

"We all know what a loss of head is suffered by the great draft made upon the pipes, shown in the feebleness of ordinary street hydrants, when any considerable number of them are in operation, and thereby giving a short supply for fire purposes, as well as in the failure of the water to flow into the upper parts of the dwelling houses and manufactories, or to feed boilers.

"Taking the Croton for example : The ample head furnished should be sufficient to give an unfailing supply in any part of almost any dwelling house in the city, while the fact is that it will scarcely reach the second story ; and every hotel or other public building is compelled to resort to the use of steam, to raise the water to the necessary altitude."

Detroit Report, of 1861, says :

"Many complaints have been made that the water does not reach the elevation, in some sections of the city, it was supposed it would, when the new reservoir was brought into use, which is attributed to a want of sufficient head ; and the propriety of carrying the embankments higher has been suggested. The top water line in the reservoir is sufficiently high to give a theoretic head above the surface of the ground as follows, at the localities named :

	FEET.	TENTHS.
Corner of Rivard and Jefferson avenue, - -	44	2
" " Woodward avenue and Jefferson avenue, - - - - - - - -	49	7
" " Shelby and Fort streets, - - -	44	10
" " Fort and First streets, - - -	43	3
" " Woodward avenue and High street, -	43	7
" " " and Holden road, -	18	11

"At the corner of Rivard street and Jefferson avenue, a good

head of water is obtained at an elevation of twenty-three feet above the surface of the ground, while it fails at the corner of Fort and Shelby streets at sixteen feet. This is to be attributed to the fact that the first is near the ascending main, and connected directly with ten-inch pipe, and the latter is a mile from it, in the central part of the city, mainly supplied from pipes four inches in diameter ; subject to greater loss of head by friction and constant draught from the pipes."

The following table shows how much the power of head is weakened by an extra number of openings—faucets:

Loss of Head from the Brookline Reservoir to Beacon Hill and East Boston Reservoirs.

The effect of increased consumption of water in the city may be seen by reference to the table in this and previous reports of *average annual heights of water in the reservoirs.*

A synopsis is given in the following table :

YEAR.	Average annual heights of Water above Marsh Level in			Loss of Head from Brookline to Beacon Hill Reservoir.	Loss of Head from Brookline to East Boston Reservoir.
	Brookline Reservoir.	Beacon Hill Reservoir.	East Boston Reservoir.		
1850.....	123.16	119.04	.....	4.12	.....
1851.....	123.36	119.39	105.06	3.97	18.30
1852.....	123.67	116.60	104.07	7.07	19.60
1853.....	122.86	114.89	104.91	7.97	17.95
1854.....	123.65	115.69	99.84	7.96	23.81
1855.....	123.82	117.79	97.49	6.03	26.33
1856.....	123.66	116.15	94.11	7.51	29.55
1857.....	124.11	114.77	94.18	9.34	29.93
1858.....	124.63	116.00	94.42	8.63	30.21
1859.....	124.07	115.24	94.05	8.83	30.02
1860.....	123.29	117.13	96.01	6.16	27.28
1861.....	123.52	116.98	96.05	6.54	27.47

5th Reason why Water Metres should be used is, to save main Conduit from danger.

As the conduit is the main artery which supplies the entire circulation, it should be the most reliable and best protected portion of the whole works. A conduit which supplies hundreds of thousands of people and animals, and innumerable manufactories, steamboats, printing engines, &c., &c., with one of the daily, hourly, indispensables of life, is to be guarded with more watchfulness and precaution than any other public work or institution; it should not be hazarded in the least degree, even for a moment. Suppose a rupture in one of these conduits to occur, which it would require several days to repair, who can imagine the consternation, distress, and even death, that might result. Yet some conduits, in order to keep up a supply against the dangerous waste, have been submitted to a severity of use which it was never intended they should be, and which the nature of their construction will not safely endure.

When the "Cochituate" conduit was built, it was intended that it should never be more than *two-thirds full* of water; but reckless waste, that never lets up, demands that it shall not only run *full*, but even under considerable *head:* the result of which was, as will long be remembered, a disastrous bursting in 1859; and still it is submitted to the same danger, as will be seen by the following, taken from the Report of 1861:

"By a comparison of the following table (the table is omitted) of heights of water in the conduit with the similar table in last year's report, it will be seen that there has been a much greater number of days this year during which there has been a large head of water on the conduit.

"The table shows the different heights at which the water

has been running, and the number of days in each month at the different heights.

"It will be seen by this table, that the conduit has been empty only four days during the year. It has been just full eleven days ; less than full, twenty-nine days ; and for three hundred and twenty-one days has been running with a head on it varying from *two inches* to *two feet eight inches.*

In alluding to a proposed enlargement of territory to be supplied, the Report says :

"It will be false economy and a great municipal error to obtain more service from the present Works than they will bear. They have been constructed with the view of performing a certain amount of supply. If an attempt is made to increase this amount, it will certainly be attended by a disarrangement of the system, and to constant difficulties which may seriously impair the whole character of the Works."

The Croton Report for 1860, speaking of shutting off the water at Croton Dam, to inspect the Aqueduct, says :

"The decision not to shut off the water proved most fortunate. On the night of the 5th December, the two main conduit pipes in Fifth avenue, which bring the water from the Receiving Reservoir into the city, were broken near Sixty-fourth street, both at about the same moment.

"By twelve o'clock the accident was reported to the Chief Engineer, and at half-past twelve he was on the ground. At this time the Lower or Distributing Reservoir, which is connected with the Receiving Reservoir by the two mains above spoken of, was found to be drained within one foot of the bottom—almost its entire supply having flowed back through the ruptured mains, and flooded the fields in the vicinity of the accident. From the Receiving Reservoir, also, there had been a very great loss of water. As soon as was practicable, at such an hour of the night, a large and efficient force was at work, and provision made for relays, to prevent any intermission of work, night or day, until the mains were renewed.

The depth at which the pipes lay beneath the surface was about twenty feet. By dint of unceasing labor, the covering was removed, the broken mains cut out, new pipes inserted, and in full operation again within fifty hours from the time when the accident was first reported to the Chief Engineer. This accident was far more extended and fuller of peril than any which has occurred since the introduction of water into our city. * * * * * Thus three-fifths of the total supply to the city were at once cut off by the accident. To preserve enough water, therefore, for the absolute necessities of domestic use, it was deemed necessary to take measures to which we have never before been compelled to resort. As soon as the force was collected and set to work, at the place of the accident, the Engineer notified, by telegraph, the whole police force, with a view to excite increased watchfulness as to fires. In the morning, orders were issued to all manufactories to cease using the water, and the entire supply to shipping, ferries, &c., was cut off. To enforce the order to the manufactories, it was found necessary to ask the aid of the Superintendent of the Police. By the afternoon of the 6th, the manufactories had been generally stopped, and the beneficial effect was felt at once. With the exception of a small portion of the city, there was then a sufficient supply for the real necessities of domestic life. To supply the portion from which the water was cut off entirely, the fire-hydrants in the neighboring districts were tapped, and arranged to give a moderate, but sufficient, supply to all comers. Fortunately, no large fires occurred in the district unsupplied by water, during this interval.

"Had the examination and repair of the Aqueduct not been postponed, the break would have occurred at a moment when the supply from Croton Dam was wholly cut off, and the Aqueduct in such a stage of repair, that to have let on the water immediately would have been impossible. With the Distributing Reservoir empty, and the Receiving Reservoir nearly so, the city would soon have been utterly without water. The results of such a disaster it is not easy to comprehend."

The same Report, speaking of a rupture in the Aqueduct, which occurred Dec. 21st, 1860, about forty miles above the city, says:

"It was found that there was a crack through the masonry of the bottom of the Aqueduct, the fissure extending about 425 feet in length, and being from one quarter of an inch to an inch and a quarter in width. Owing to the great length of the required repairs, the difficulty of making cement set properly during such cold weather, and the limited force which could be procured, there was, at first, danger of another very serious interruption to our water supply."

By general use of metres, the causes of some of these accidents would be prevented, as well as the disaster when they do happen, by causing the Reservoirs to be always full when they occur, and causing an economical use of what water might be on hand at the time.

6th Reason why Water Metres should be used is, to render extension of Water Works unnecessary.

The ever-increasing tendency to waste the water, together with the rapid increase of population in our cities, not only has already made it necessary to expend vast sums of money for the extension of water works, but, unless the system of rates be so changed as to make every taker pecuniarily interested in cutting off the waste, the time will soon come when most of our cities will come short of supply and call for expensive extensions. However great may have been made the original capacity of supply, with a view of meeting anticipated demands, yet the capacity of supply is *fixed*, while the increase of demand is *indefinite*. It is an error to suppose *any supply*, short of the Mississippi, cannot, or will not, be exhausted, when we know, by actual facts and figures, that a single

water-closet will consume from 8,000 to 12,000 gallons per day. As many water-closets as there are water-takers in New York City (say 60,000 at 9,000 gallons each) would consume 540,000,000 gallons daily. This is *eighteen* times as much water as the whole city consumes (30,000,000). The minimum supply of Croton River is 27,000,000 gallons. Now, suppose the maximum average supply of the Croton River, when parts of several counties of the State and a portion of Connecticut shall have been converted into an accumulating reservoir, to be 50,000,000 gallons per day: even this amount would supply only 5,555 water-closets at 9,000 gallons per day. Yet there are 6,373 hopper water-closets in the city of Boston, and, with other water-closets and urinals, altogether 12,843 It will be said, that there will not *be* 5,555 water-closets consuming this amount of water. We do not expect there will; but there is vastly a *larger* number, each consuming *less*. Besides, water-closets are only *one* of the minor, among thousands of other and greater, sources of waste and demands for water. These closets show the *temptation and* POWER *to exhaust*. Think of the entire Croton River being driven through 5,555 water-closets! Yet it is *possible*—the streams are small, but their *rapidity!*

The Croton Department has just expended one million and eighteen thousand dollars for extensions, and must go on expending more for an immense impounding reservoir.

The Boston Report for 1861, speaking of extensions, says:

"As the consumption of water increases very fast, and as the lake supply will very soon all be used in the city, I most respectfully suggest that no time be lost in having the neces-

sary surveys made to determine a new source of supply for the city, as recommended by the Mayor in his Inaugural Address of the present year."

The Baltimore Report for 1861 says:

"But, before closing this report, I take the liberty of expressing the individual opinion, that even when finished to the fullest extent of the present plans, these works will still be incomplete, and to advise the Board of the vital importance, if not absolute necessity of immediately extending the Hampden Reservoir to a full circle (so as to double its present capacity), of constructing another low-service reservoir, similar to the present one, at some suitable point on the eastern side of Jones's Falls, either within or near the city limits, and of connecting these two improvements with each other, and with the city mains, by an independent line of pipes."

Other cities are agitating the subject of extension.

7th Reason why Water Metres should be used is, to enable smaller towns and cities to afford public water.

If the use of metres would prevent waste, and cause a reduction of two-thirds in the aggregate consumption of water—making *thirty* gallons go as far as ninety, without at all diminishing its practical uses—then they would, of course, diminish the original and current cost of supply; for it is evident that water works capable of supplying only *thirty* gallons per day to each inhabitant of a given village or city, would cost less than those adequate to furnish *ninety*. The streams or sources of supply being less (in capacity), they could be found (in many places) nearer at hand; thus lessening the length, as well as diameter, of the main conduit; all the main and distributing pipes would be less; the reservoirs would be less in size, strength and number; the first cost and running expenses of the

pumping apparatus would be much less. In short, the aggregate cost of supply for a given city or village, probably would not fall much short of *one-half less*. Thus, by the economy which would be instituted by the use of metres, a town or village of ten thousand inhabitants, could supply itself with public water at a cost which is now required to furnish a population of five thousand. When it is considered that public water works constitute a mighty mutual labor-saving institution, and a universal dispensary of life and happiness, and a common protection against the dangers of disease, stench, and fire, it seems strange that any compact village or city, of three thousand or more inhabitants, should not, ere this, have been provided with so great a means of civilization, and it can be accounted for only on the ground of the anticipated enormous original cost of such works

There are many commodities and pleasures which would be measurably dispensed with *instanter*, provided their cost should be *doubled*. So there are many means of enjoyment and comfort which would be afforded by thousands who now deprive themselves of them, provided their cost should be *reduced* one-half. As this is true with all people, and as public water is for all, and is to be paid for by all, so, if its cost could be reduced one-half, all would be more inclined to vote for its introduction. *Who would not give a dollar a year for public water?* Yet, at this rate, a village of seven thousand inhabitants could furnish itself with water works costing one hundred thousand dollars, allowing six per cent. interest on the funds, and one per cent. for wear and tear. There are thousands of places in the United States alone, where one hundred thousand dollars would amply provide public water to even a much larger population than this, on a basis of thirty gallons per head, which

cannot afford the cost of ninety gallons per head. Alluding to this branch of the subject, Mr. Rhodes says :

"It is not too much to state, that the size and cost of pipes for city water works, as well as of the reservoirs, could be reduced one-third, if the quantity to be furnished could be calculated without reference to the unknown quantity of waste."

8th Reason why Water Metres should be used is, to prevent the exposure of lead pipes alternately to air and water.

The waste and consumption during the day so far reduces the head of water in the reservoirs, that the lead pipes in all the more elevated portions of the city become exposed to air ; while at night they are filled again with water. It is this *alternate exposure to air and water* that renders lead pipe so dangerous for the purposes of conveying water. A full head in the reservoir would remedy this evil. How far metres would insure a full reservoir may be judged by what is said in other parts of this treatise. On this subject, Mr. Rhodes says :

'I would here advert to a consideration which I deem of the utmost importance, although it seems not to have been the subject of much public comment. It is the great danger to health incurred by *exposing lead pipes*, in the upper part of dwelling houses, *alternately to the action of water and air.* In the night time, when the head increases, the pipes are full, and in the day time they are again emptied. This is the surest way of promoting the formation of the poisonous carbonate, according to the views of writers on this subject.

"I pass this point, after saying that, in my opinion, it is one of the most important of all involved in the subject, and demanding the attention of capable minds."

9th Reason why Water Metres should be used is, to cheapen the price of water for all, especially for manufacturing and other business purposes.

Some wise man has said, "He who makes *two* blades of grass to grow where only *one* grew before, is a benefactor of his race." So, too, that which *cheapens* the price of any needful article, must be accounted desirable and useful. That metres would cheapen the price of water is evident; for, the waste being prevented, the present supply, without increase of expense to the city, would at least furnish double the present number of takers, hence each taker would receive water at *half* the charges without diminishing the water revenue. The rates, upon this principle, being reduced, there would be a corresponding increased number of takers. There are many persons deterred from using public water by the high rates, who would be willing and glad to pay half the present prices.

The prosperity of a city greatly depending, as it does, upon manufactories and mechanical pursuits generally, of course, water, as well as every other possible facility, should be afforded at the cheapest rates, and as many branches of such business necessarily consume vast quantities of water, they cannot afford to pay more than its *actual cost;* but they *can* afford to pay *cost*, for the quantity they *actually* require. But the city cannot furnish such large establishments at cost, when *they*, as well as the takers for domestic purposes, waste one half, and more, of all the water for which the city receives *no pay at all.* A gallon of water *wasted* costs the city no less than a gallon *used.* Yet many a private house wastes as much water as would supply the *actual* wants of the largest manufac-

tory; hence a penal price must be charged. On this point Mr. Rhodes, alluding to the cost of water, says:

"This statement of the cost of water testifies strongly of inability, under the present system, to assess the expense equitably. It is no more nor less than a confession that one consumer must pay for the waste of two or three others; consequently, wherever metres are applied under these rates, the expense almost prohibits the use of water for manufacturing and other purposes. A late report of the Croton Board gives the case of two sugar refineries, one of which was taxed $3,433 per year, and the other $1,202 per year. As the consequence of these high rates, every large manufactury is compelled to make expensive provision, by means of pumps and cisterns, to reduce the consumption of water furnished by the city.

"It is fair to conclude that the tariff of water rates, established in almost all our cities, is designed rather for the purpose of restraining the use of water, by inflicting a penal sum, than for the purpose of developing the necessary revenue for the use of the Department. What policy could be more detrimental to the general interest of the city than one so oppressive as this to its industrial pursuits? Because they are considered large enough to be worthy of attention and measurement, they are compelled to pay four times as much in their manufactories, where they really need and use the water, as they or their neighbors do in their houses, where more than half is wasted. Our city has taken a wiser view of this subject, and fixed the rates of manufactories at one (1) cent per hundred gallons, deeming it well to foster the manufacturing interests, although it may be, with the present limited number of takers, at some loss. The good effect of this policy is already perceptible."

The Cincinnati Reports of 1861, alluding to the introduction of metres, says:

"All consumers would then pay for a close approximation to the amount used, and no more. The enormous waste of

water, attendant upon the present system, would then be either stopped or paid for, and the works would be enabled to furnish the supply to all, at a proportionately reduced rate

10th Reason why Water Metres should be used is, to enable water boards to regulate the price of water to meet the cost.

The price of water from year to year, as the number of takers increases, could and should be diminished; for water can be afforded at cheaper and cheaper rates, until the consumption equals the full capacity of the supply. But under the present systems of fixing rates, together with the uncertainty in regard to the amount of waste, it is impossible to thus gradually reduce the price in keeping with the above principle. But the measurement system would enable the Department to vary the rates from year to year, according to the increased number of takers, with a degree of nicety that would cause the yearly revenue to closely approximate the yearly cost. In the first place, the amount of consumption amongst takers would be more uniform, and, therefore, would furnish a basis for more definite calculation, whilst the metres would furnish the means of varying the price per hundred or thousand gallons with the greatest facility and accuracy. Even the *tenth or hundredth* part of a *mill* could be assessed, more or less, any given year, on any fixed number of gallons, without the least expense or difficulty.

11th Reason why Water Metres should be used is, to facilitate the changing of rates to meet the varying quantities consumed at different times by the same takers.

It is well known that the amount of water consumed in many large establishments from time to time varies ac-

cording to the amount and kind of business carried on for the time being. It is difficult to ascertain these changes, and readily vary the rates, so as to insure justice to both consumer and supplier. But a metre placed in such an establishment would always adapt itself to the exigencies of the case, and truthfully tell the tale in justice to both.

The Chicago Report for 1861, alluding to this subject, says:

"As you are aware, it is a matter of much difficulty to test the actual water receipts with the amount of water rates assessed. A very considerable portion of the collections is from consumers whose rates are changeable—depending upon their amount of business and kind of business—and in actual practice from one cause and another, as many as twenty changes, some increasing and some lessening the amount to be collected on the books, will be made in one day. Such changes in the course of the year will probably number over a thousand, altering from day to day the amount of water rent recorded in the books at the opening of the year."

12th Reason why Water Metres should be used is, to increase revenue of public water without increasing the rates charged.

After the works are built, it costs no more to deliver as much water as the pipes and source are capable of furnishing, than it does to supply less. Hence, if consumers were to pay as much for the amount of water they *really need* as they *now* do for what they *use and waste*—and there is no reason why they should not—the aggregate amount now consumed would furnish double the present number of takers. It may be said, however, that even if the water were thus economized, there would not be, necessarily, an increased number of takers. But

it necessarily follows that the city could thus furnish double the number of consumers without an increase of expense; and it is safe, therefore, to conclude that an inducement offered by a reduction of rates—which it would thus be possible to afford—would produce more than a corresponding increase in the number of takers, and a consequent augmentation of revenue. By referring to the table on page 29 it will be seen that, taking ten of the principal cities, only about *fifty* per cent. of all the inhabitants are consumers of public water. There is no good reason why the entire population should not be consumers, and so *diminish the rates* and *increase the revenue.* —To supply the *least number of consumers at the highest rates* is not in keeping with the popular idea of furnishing public water, or the spirit of public enterprise generally, which is to furnish *the needful supply to the greatest number of consumers* at the *least possible rates*, that will render such enterprises self-sustaining. The present methods of charging for water are in direct violation of this general principle; for, so long as there is no check put upon the boundless waste, it will be impossible for Water Departments to furnish water at the cheapest rates, or even to obtain the necessary revenue without ultimately increasing the rates.

This is illustrated by results in Louisville, where the total *cost* of water delivered was nearly 29 cents per 1,000 gallons, and the *revenue* received was only 5 cents per 1,000 gallons, whereupon the Louisville Report for 1861 says:

"This is an enormous cost per 1,000 gallons of water delivered, an unusually small amount of revenue derived for each 1,000 gallons distributed, and is not owing to any inherent defect in the works, but wholly arises from the too limited patronage this public improvement has so far received.

"The works, *with the current expenses the same as at present, excepting fuel*, can deliver and distribute, with perfect ease, 4,000,000 gallons of water daily, which, if paid for at the rate of $9\frac{58}{100}$ cents per 1,000 gallons (the *actual amount* received for each 1,000 gallons distributed in Cincinnati, Ohio, although making the assessments at the rate of 12 cents per 1,000 gallons) would bring a revenue of $139,868 per annum, an amount more than sufficient to pay the interest on the bonds and all current expenses; and, at the same time, furnishing only 55 gallons of water to each inhabitant per day, while at present, estimating fifteen persons as using the water for each permit granted, the consumption for the past year has been, on an average, $73\frac{6}{10}$ gallons for each person per day."

The Brooklyn Report for 1861, speaking of the measurement system, says:

"Should this system be adopted, although the immediate outlay for metres would be a large one, the *additional revenue received* would, we believe, in three years, *more than compensate the treasury*, and do much to relieve that section of the city lying beyond the pipe district from that large proportion of tax which, under the present rates, it is now called upon to contribute."

The New York Report for 1855 says:

"Being of opinion that the application of metres to *all buildings* would *repress the waste and increase the income* of the water, the Board will be disposed gradually to introduce the system, under a suitable law, by way of experiment, so soon as a metre shall be produced which will be sufficient, and come at a price low enough to justify the payment for the cost."

The same Report for 1853, speaking of metres, says:

"Some of those now in operation have cost $450 each, ranging down to the smallest at $35, exclusive of the cost of fixtures and setting them. The expenditure for metres during the year amounts to $3,650, *all of which, and more, will be re-*

turned to the treasury within the first year by the increased charges against the establishments to which they have been affixed. Such being the result, the Department considers it a duty to extend their application till all the most important consumers are brought under this satisfactory test."

The Chicago Report for 1861, alluding to metres, says:

"Wherever it has been thought best to introduce them, and they have been kept in order a sufficiently long time, they have *more than paid for themselves* by the increased rates they showed should be charged."

In Boston, where metres were placed on eight hotels (see page 48), it was found that the difference between the sum of rates by *calculation* and by *metre* was $2,225.22 in favor of the metre; that is *eight metres increased the revenue* $2,225.22 *in one year.*

Suppose these metres to cost but $278.15 each (an outrageous price), and they thus pay for themselves every year.

Again: suppose these metres would stand only four years, and that then they be thrown away, *the revenue would be increased* $8,900.88 *by the use of eight metres for four years, or* $1,112.61 *by the use of one.*

Allowing that each metre ought not to cost more than $112.61, and we have *in four years* ONE THOUSAND DOLLARS *net increase of revenue by the use of a metre on a single hotel.*

FANCIED OBJECTIONS TO THE METRE SYSTEM OF CHARGING FOR PUBLIC WATER.

1st. Some think Water should be free as Air, to all.

Very well, it *is* free as air to all, if all will go where it is, to the rivers and lakes, and help themselves. So are the *fish*, in the rivers and lakes, free to all, if we go where they are and catch them for ourselves. But *fish*, when they have been caught and brought to market, must be *paid* for. So too with *water*, when it is brought to us from great distance, through artificial canals, conduits, pumps, reservoirs, pipes, faucets, etc., innumerable and vastly expensive, and then, after we have used it, carried away through culvert and sewer to the river again, costs something too, and *must be paid for*. God, in his goodness, has made lakes, rivers, and springs, and trees, and given us strength and ingenuity to dig wells and make pumps, but nature is not so accommodating as to lay iron pipes above and below ground to bring water to our very kitchens, bedrooms and bath-tubs. It is not the water itself that costs anything, but the *conveying* of it. If you would have a *well* you must *dig* it; a *pump*, you must *make* it; and then the pump must be *worked* and the water *brought*.

When the magnitude of the original cost and current expenses, and the untold conveniences and blessings of having such a supply of water—and the utter impossibility of otherwise procuring it—are appreciated, none but the thoughtless and ungrateful will say that public water ought

to be "free as air." This is a fallacy. They who believe it practice no economy; and though they submit to a nominal charge for water, they feel that, by so doing, they are entitled to consume as much as their pipes will convey, heedlessly *caring not* whether it be *used* or *wasted.* Hence these are the *very* persons who should be taught a better way by the application of metres; they are not otherwise to be safely trusted with the use of public water: while there are, at least, three good reasons why all *honest* and *economical* men will desire—at any rate not object—to have metres.

1st. If they are now consuming less water than they are paying for, the metre will tell them so, and they will be the *gainers.*

2d. If they are using *just* the quantity they are paying for, the metre will tell them *this*, too, and they will neither *lose* nor *gain.*

3d. If they are consuming *more* water than they are paying for, the metre will tell them *this* also; and, if they be truly honest, they will not desire to enjoy for years to come an indispensable necessary of life—as they may have been doing for years past—at the expense of their neighbors.

2d. Others, who think it right to be charged for water, think they will be obliged to pay more with than without metres—that they cannot afford to pay for water by the gallon, etc.

By the use of metres it is not proposed to charge takers any more per annum for water than they now pay, on the contrary, not so much. It will be said, for instance,

"How can I afford to sprinkle my yard and the street, wash my carriage, douse my water-closet, etc., etc., and be charged for the water by the gallon?" Why, that depends *entirely* upon what PRICE per gallon you are compelled to pay. We *now* pay by the gallon, if we divide the water tax by the number of gallons used, but it is a very *small price* per gallon; so will it be when we are supplied through the metre. In short, it is only the COST of water that citizens ought to be called upon to pay, which, of course, is the very *least* that *can* be charged. Now, if the entire yearly cost is divided by the whole number of gallons annually delivered to the city by the works, of course, it will bring each gallon to the very lowest price possible; but if *sixty* gallons out of every hundred are wasted, and return no revenue, then the remaining *forty* gallons must pay correspondingly higher rates to support the works. Hence, if for each and every gallon a fixed minimum price—viz.: its part of the whole cost—be charged, and so every gallon, whether it be used or wasted, by passing through the metre, be necessarily paid for, and so return its own part of the cost to the revenue, why, of course, *each* and *every* taker would necessarily receive any amount of water he might choose to consume at the very lowest price per gallon, at which it is possible for the city to afford it. This is the gist of the whole subject, viz.: *to make each and every gallon bring a revenue equal to its own actual cost—no more, no less.* Not to make the 25,000 gallons now used, per annum, by a prudent family bring as much revenue as the *ten* or *twenty* or even a *hundred* times as many gallons used and wasted by their more extravagant neighbor.

This would bring water at such cheap rates that no

consumer need spare the use of it, in the least, for any needful or luxurious purpose.

This naturally brings us to consider the cost of water.

Actual cost of water compared with the prices charged.

As general averages are more reliable than special, we will take the general average of actual cost of water per gallon of six of the principal works in the United States, viz.: those of New York, Boston, Brooklyn, Chicago, Cincinnati and Detroit, which is only EIGHT MILLS *per* 100 *gallons*—or *one cent* for *four barrels.*

The general average price *charged* is about THIRTY-TWO MILLS *per* 100 *gallons*, being, as will be seen, FOUR *times the actual cost.*

This great difference in *price* and *cost*, under the present methods of fixing rates, is unavoidable because the greater portion of the water is wasted, for which the city receives no revenue at all.

The following table shows the yearly and daily number of gallons that different sums (from $1 to $21) would buy at cost price, and at the average price now charged:

Cost price.	Number gallons per day at *cost.*	Number gallons per year at *cost.*	Number gallons per day at *present price.*	Number gallons per year at *present price.*	
$1	34	12,500	9	3,125	$4
2	68	25,000	17	6,250	8
3	103	37,500	25	9,375	12
4	137	50,000	34	12,500	16
5	171	62,500	42	15,625	20
6	205	75,000	51	18,750	24
7	239	87,500	59	21,875	28
8	278	100,000	68	25,000	32
9	308	112,500	76	28,125	36
10	342	125,000	85	31,250	40
11	376	137,500	93	34,375	44
12	410	150,000	102	37,500	48
13	445	162,500	110	40,625	52
14	479	175,000	119	43,750	56
15	513	187,500	127	46,875	60
16	547	200,000	136	50,000	64
17	581	212,500	144	53,125	68
18	616	225,000	153	56,250	72
19	650	237,500	161	59,375	76
20	684	250,000	170	62,500	80
21	718	262,500	178	65,625	84

The right hand column shows the present prices, that correspond with the cost prices in the left hand column.

That the present prices charged are as high, or even higher than we have estimated in this table, will be seen by the fact that private houses in Boston are charged per one hundred gallons, *six cents;* in Detroit (for factories, breweries, hotels, stables, etc., etc., per metre measurement), *five cents;* in Philadelphia, *five cents;* and, in New York, from *three to five cents;* giving for these four cities an average of about *five cents* per one hundred gallons, instead of about *three cents*, as we have allowed in the table.

Any person, therefore, who thinks the measurement system will bring water at too high a price per gallon, can see, by this table, that he would receive *four times* as much water for the same money as he is entitled to consume under the present system and rates. He will see, also, that the amount of water (at cost price) standing opposite to any number of dollars (in the left-hand column) is more than ample for any purpose for which he may be paying for water; whether it be for family use generally, or for bathing apparatus, water-closet, garden hose, horses, carriages, fountains, etc., etc. For instance, if $5 is charged for bathing apparatus, opposite to $5 in the left-hand column will be found 62,500 gallons per annum, or 171 gallons per day.

Suppose a taker to pay even less than he now does, say, per year,

For house purposes.....	$8—	100,000 gallons.
" horse and carriage...	$2—	25,000 "
" bathing apparatus...	$3—	37,500 "
" water-closet	$3—	37,500 "

This gives 200,000 gallons for $16, or *eighteen barrels per day for* FOUR CENTS AND A-HALF.

If a hand-pump were placed in a kitchen, free of cost, this quantity of water could not even be *pumped* for *ten* times this money, to say nothing about bringing it from a pump in the street, besides carrying much of it up two or three flights of stairs, and then, after it is used, to the gutter.

Let him, then, who grumbles about the application of metres and the charges for water examine these statements, and he must be convinced that public water works, for the

money paid, perform more of his labor, supply more of his wants, and do more to promote his health and happiness than any work or institution of art. At cost price to consumers, public water, for *cheapness* and *comfort*, stands next to *rain, air and sunshine.*

The cost of pumping public water.

Most of the works, in order to secure sufficient "head," are compelled to resort to pumping; and as this part of the process of furnishing water is very expensive, an allusion to it in this connection will not be out of place.

The machinery and buildings are expensive, while the wear and tear on the boilers, engines, and pumps are necessarily very great, yet the chief consideration is the *constant expense of attendance and fuel.* Drops of water, it is said, will wear a hole through a rock. So, too, with taxes and expenses, though they be small, yet, if constant, they will amount to the interest of an enormous sum.

The average cost of pumping is about one mill per 100 *gallons.* At this rate, the cost of pumping for a city, consuming, say, 10,000,000 gallons per day, will be $100 per day, or $36,500 per annum. Now, if seven per cent. interest will cover cost and wear and tear, for instance, of the main conduit, then a conduit, that costs $521,428, just equals the expense of pumping for such a city. If three-fifths, or sixty per cent., of public water be wasted, as we have seen it is, then the expense of merely *pumping* what water is *wasted* by a city, whose daily consumption is 10,000,000 gallons, is $21,900 per annum, being the seven per cent. interest of $312,856.80.

As a rule, too, those works which pump water have a higher head, and the greater the head the greater the waste.

In view of this, and the extra expense of elevating water, metres are more needed on those works which do, than on those that do not, depend upon pumping.

3d. Some say the Cost, Repairs, and Inspection of Metres will make additional and useless Expense.

Of course, every new thing makes *additional* expense, but whether it be *useless* or not, depends upon the amount of consequent benefit. Over a million of dollars additional expense has already resulted in the *extension* of the Croton Works. This is not *useless* expense—in the absence of metres, it were needed. Still even this very expense might have been avoided for years to come had it been possible to procure a reliable and sufficiently cheap metre.

This objection about additional expense is answered all along in the foregoing pages; but for its further refutation, we contend that it is no less absurd to object to the introduction of water metres, on account of their reasonable expense, than it would be—because they cost something—to object to the use of *gas metres*, *scales* and *yard-sticks;* in short, all weights and measures, and so adjust everything on the less expensive plan of "guess work" and "grab game."

Storekeepers do not guess at pounds of sugar and gallons of molasses, on the ground that the cost of scales and measures would be "additional expense," but they buy these adjusting utensils, and charge their cost into the said sugar and molasses—this being the only plan which will

satisfy their customers. People will not offset the *risk* of receiving *less* against the *chance* of receiving *more* than a gallon, save only of water.

4th. Some say Water Metres would be turned to Political Account.

Though it be true that scheming politicians seek their aids from far and near, from regions both high and low; leaving no stone unturned, and turning everything to their own account, yet we fail to see how they can bring water metres to their aid. It has been said the water metre inspectors would vote for their principals, in order to retain their own positions. This, if it be any reason at all, can be urged against any public office; therefore, on the same ground, why not abolish all public offices, to prevent them from being turned to "political account," or any other useful thing or institution which can be at all politically handled.

5th. Others say the Metre Inspectors would collude with Consumers, and render false Reports.

This is no more of an objection to water metres than to gas metres, or any other checks, registers, or guages. Any and every person who is intrusted with responsibility may collude with another—clerks, conductors, cashiers, etc.; *all*, from a toll-collector to a Congressman. If a man in office or trust is found dishonest, he is discharged, and *another* put in his place, but the office remains. If there were no reason but this against the use of metres, it would be no more sensible to urge it than to advocate the discontinuation of the New York Post-office in case one set of its clerks should be found dishonest, or likely to vote for a certain Governor or President.

6th. Others think Metres would be tampered with by the Consumers.

If metres are properly constructed and attached, it will be impossible for consumers to disturb their operation. Besides, the temptation to interfere with a water metre is not near so great as it is to disturb the *gas metre*, as the amount paid for gas is several times greater than that paid for water; yet this objection has not prevented the successful and general introduction of such metres. When *eighteen barrels of water cost only four cents*, it is preposterous to suppose takers would tamper with the metres to save a few *gallons*. This is not a valid objection. There is no more probability that consumers would disturb the water metres than the water pipes or gas pipes. Again: suitable penalties would deter takers from attempting any interference.

7th. It is thought, by some, that Water Metres would be liable to "freeze up and burst."

Anything containing water will "freeze up and burst," if it be placed where it is sufficiently cold. Water *pipes* will burst if they are allowed to freeze up; so, of course, would water metres; gas metres freeze unless they are properly located or filled with non-freezing fluids. People do not store vegetables where frost can reach them; if they do, they expect them to be frozen. Neither is it intended to place water pipes where *they* will be frozen. To do so, would be no less absurd than to drive a nail with a watch, and then complain that the watch would not keep time. Who says a watch is not a practically useful article, because it will not stand nail-driving? Why object to metres because they will freeze up if exposed to

frost, when it is never *intended* they shall be thus exposed. It is a very simple and inexpensive matter to place metres out of the reach of frost.

In Boston, where the winters are long and severe, the number of leaks produced by *frost* in service and two-inch pipes is very small when compared with those produced by *other* causes.

The Boston Report for 1861, alluding to 399 leaks in service and two-inch pipes, says :

"One hundred and twenty-two were caused by the settling of earth, thirty-eight by stiff connections, nineteen stopped by rust, twenty by frost, forty-one by defective pipes, twenty-six by defective couplings, sixty-four stopped by fish, fifteen by defective cocks, eleven gnawed by rats, twelve struck by picks, fourteen by defective joints, nine by digging drains, four stopped by gasket, three by cocks blowing out, one by tenants."

Here are several causes of leaks ; but, think of objecting, for instance, to the introduction of water because rats are liable to gnaw off the service-pipe! Yet it is just as sensible to object to the introduction of water, because rats sometimes gnaw off the service-pipe, as to object to metres because they will freeze if subjected to frost.

8th. Some admit the Importance of applying Metres to Factories, Hotels, etc., but think they are not needed in private Houses.

It is admitted that metres are needed on large establishments, because they consume large quantities of water and are liable to allow much of it to be wasted. But, as regards the consumption of water and the application of metres, what is the difference between a *hotel* and a *block of ten houses* that may contain an equal number of servants,

occupants, baths, wash-basins, etc., and therefore may consume or waste an equal amount of water. If there be any difference, it is in favor of applying the metres to the ten houses, because there are *ten* takers instead of *one*, who demand satisfaction and justice. Besides, there are *ten* takers instead of *one* to be looked after by the Department. Again: it is possible, if not probable, that among the ten houses there will be *one water-closet*, even, uselessly consuming as much water as would be a reasonable supply for all the wants of a hotel. There are *ten* takers instead of *one* who may practice deception in their consumption of water.

It will be said, notwithstanding this may be so, that metres cannot be *afforded* for every house. But it has been admitted, by all the water boards that have used metres at all, that wherever they have been applied *they have more than paid for themselves in a short time;* some of them even, in *three months*, have returned to the revenue more than their cost, this, too, when the metres have cost, some of them, as high as $450 each. Whereupon, the boards freely and fully admit the feasibility, and the correct policy of applying metres, notwithstanding their present high price, to all establishments consuming large quantities of water.

Now, if the cost of metring, say 3,000 to 9,000 gallons per day, in a *factory* or *hotel*, can be profitably afforded, with a metre that costs, say, from $100 to $300, which (allowing twenty-two per cent. per annum for interest and wear of metre), is from *two to six mills* per 100 gallons; then, most certainly, the same sum ($100 to $300) for ten *small* metres can be profitably afforded for metring the same quantity (3,000 to 9,000 gallons) per day for the *ten* houses. This would be allowing from $10 to $30 each for

the house metres—yet they can be constructed so as to be afforded to the Department for a price nearer $10 than $30 each.

The rate of cost per gallon for metring being the same, of course, it matters not at all whether the quantity metred be *large* or *small*; whether it be consumed in a hotel, hospital, factory, brewery, livery stable, kitchen, or elsewhere.

Again: if water can thus be *profitably* metred at the rate of from *two to six mills* per 100 gallons, *much more* can it be afforded if the metring can, by the production of cheaper metres, be brought down to a small part of this cost. Besides, if it be so profitable and desirable to metre a small portion of all the water consumed, as in hotels and factories, then, *much more* would it be profitable and desirable to metre the entire consumption.

9th. It is urged, by some, against the introduction of Metres, that the water rents cannot be collected in advance.

This objection could be obviated by holding the landlord, or the house itself, responsible for the water rents. If this be not possible, under existing statutes, there is no reason why the laws should, or could not be changed; for, if public water be essential to the welfare of cities, and it be impossible to successfully manage its distribution without the adoption of metres or any other needed improvements, and these improvements cannot be made available for want of statute privilege, then there is no doubt, when this shall be made to appear, but the proper authorities would make such changes or modifications of the law as to render possible the adoption of an improvement so essential as the metre.

In cases where the takers are tenants, and the lien system on the property is not in effect, they might be required to advance a certain sum sufficient to cover the probable water rent; and by inspection of the metres before the expiration of the period which it was supposed the advanced money would cover, it would be seen whether or not the sum advanced was adequate to protect the Department against chances of losing in any particular cases, and if it were not, to call for a further deposit.

If gas companies manage to secure the payment of their bills under the metre system, what is to prevent the successful operation of the same system in the collection of water rents? Nothing, necessarily.

10th. It is said, as an objection, that a Metre for every house would cost an enormous sum.

So do water works themselves cost vast sums—so do their extensions. The Croton extension, yet incomplete, has cost over a million dollars. But so long as *any* useful improvement is worth more than its cost the cost is not to be considered. Otherwise, its cost might have been urged against the Croton extension, or even against the original introduction of the works, and so let the people go dry and unwashed. So, if metres would remove the necessity of making extensions, more expensive than themselves, or would be the means of rendering the works in every respect worth more to the city by a sum far greater than the cost, then the magnitude of the aggregate cost should not be an objection, so long as means can be commanded at reasonable rates of interest.

If a *thousand* dollars' worth of metres will pay for themselves in a short time, and it therefore be desirable to purchase them, then would *one hundred thousand* dollars' worth,

or more, pay for *themselves* also, and therefore it would be desirable to purchase and apply them.

The following article, from the *New York Daily Times* of December 8, 1860, being so pertinent to the general subject we insert it. It was published at the time so many people were deprived of water by the accident to the "mains" in Fifth avenue:

WASTE NOT, WANT NOT.

"It is a good thing to whistle for water once in a while, like the dry faucets in our houses. If an occasional antepast of the legitimate and fast-coming results of our habitual waste of Croton does not teach us a better system of water rates, we had better tap Lake Erie at once; for where people are charged, not for what water they want, but for what they *can waste*, no ordinary river will insure high tide in our reservoirs. . . . . It is the unanimous belief of all persons who are conversant with the actual working of our system that water must be *measured out* to consumers.

"The present plan is to charge a certain class of dwellings with a certain amount of water, and a smaller class with a less amount, irrespective of the number of consumers, their habits of ablution, the number of hours per day occupied in washing the sidewalks, barrels drawn to get a cool tumbler full to drink, the number of faucets left open all winter to prevent freezing, in short, irrespective of the amount used, just as if a house consumed water in proportion to its cubical contents, any more than in proportion to the color of its carpets, or the style of its furniture; just as if an inch pipe would not discharge at least as much wide open, behind a brick wall, as it would when partially closed inside a brown stone front. Metres experimentally applied have shown, in some cases, ten times as much consumption of water in one house, as in another similarly rated.

"It is totally impracticable to get at the amount of water which passes through openings of an unknown size, without measuring it. Yet, this is the basis of our present system—an excellent system of guesswork, too—whose best result is, that water works intended to be ample for future generations are inadequate to-day, while the total supply, divided by the number of consumers, "gives," we say, an abundance to each. When we contemplate the facilities for waste, we shall only wonder that there is any left to use. The mere neglect to close a faucet here and there about a house, multiplied by the number of our houses, at once converts the entire system into a sieve, which drains our reservoirs faster than spring freshets can fill them. And this neglect inflicts no punishment on the offender—it gives no warning to careless servants—it does not even betray its extent or locality to the disconsolate Department; but the ten thousand little streams noiselessly and industriously run away with our precious Croton to the sewers, and the tax-payers build new reservoirs to meet increasing waste.

"It would be absurb to object, in this connection, that a plenty of water and any possible amount of aqueducts to fetch it, is the fundamental condition of the

public health. If the advantages of the hydropathic treatment are so great as to warrant the use of 1,000 gallons a day by a small family, it is certainly worth paying for—so think the neighbors who manage to exist on 200.

"But it is waste, not legitimate consumption, including three baths per day, if necessary, that demands the reform. When people have to pay for all the water that passes through their premises, the city can afford to supply it, without calling upon those who are content with enough to pay for new reservoirs and aqueducts. In fact, the city would make a capital speculation by supplying water at the ordinary rates for any ultra individuals who might want to set up sawmills or emperor fountains in their back yards. There is no difficulty in supplying water to all who are willing to pay for it. But to levy the charges on the principle that all the houses of a certain size receive a certain amount of water, is as absurd as it would be for grocers or gas companies to supply wine and light at so much per cubic foot of dining-room.

"The water metre is, in fact, likely to be more important than the gas metre, in proportion to the cost of the respective works, for furnishing the supply. The city might afford to furnish gas *per capita*, for people could not conveniently and safely waste ten times, or even twice, as much as they might need. But to push aqueducts to the Housatonic and the Upper Hudson, for the purpose of testing how much people *can* waste, is another matter altogether.

"If our citizens had to pay for all the water delivered to their houses, while it is probable that waste would be instantly cut off, and that the present works would be ample for years to come, it is certain that the amount of waste would be quite immaterial to tax-payers.

"In the present dearth, therefore, as we go without our accustomed baths, as manufactories stop for want of steam, and as we even import water in hogsheads from Brooklyn, let us remember that this will be the habitual state of affairs before long, if we do not either measure the delivery of the precious Croton, or build a new aqueduct or two, if that extravagance should appear better suited to the state of the times."

WHY WATER METRES HAVE NOT BEEN GENERALLY ADOPTED.

If, as we have shown, water metres are generally indorsed, and called for by Water Boards, and there be so many good reasons why they *should*, and no valid objection why they *should not* be introduced, why, then, have they not come to be generally adopted? Because there has been, heretofore, no metre to be found, sufficiently cheap and otherwise suitable for general use.

As, formerly, the various supplies of water were supposed to be inexhaustible, it is only within a few years that water metres were thought to be at all needed. Hence, in keeping with a well-known principle—that, prior to their demand new discoveries and inventions are not developed—it is only recently that inventors have turned their attention to this subject.

Notwithstanding, however, the need of water metres is so recent, yet, in consequence of this increasing and untold waste of water, it has suddenly become a pressing demand, and is rapidly becoming an absolute necessity, in view of which, inventors have of late brought out many curious and ingenious devices; most of which, however, being such total failures, it would seem as if success were impossible; that inventors, for once, were to be baffled and obliged to abandon their undertaking. But this class of men, accustomed to disappointments, are not easily discouraged. They hold that the same ingenuity and skill that can divert and bring down to the metropolis whole

rivers, and drive them a thousand feet high, then make them flow under the solid pavements to every house; supplying every shop, laundry, kitchen, dining-room, and bedroom with a "living stream" of water, can also develop the means of an *equitable and economical distribution* of such a blessing.

This brings us to the consideration of water metres themselves—their construction, difficulties in the way, &c.

DIFFICULTIES IN THE WAY OF CONSTRUCTING A RELIABLE WATER METRE.

On first inspection it would seem, *theoretically*, to be quite an easy undertaking to construct a suitable water metre; but, *practically*, there are difficulties in the way, which it has been no easy task to overcome. Some of the more prominent of these are:

1st. The sediment and other impurities in the water.

There are several impurities in river and lake water. By chemical analysis of twenty-three specimens of water, taken from rivers and lakes of this and foreign countries, they were found to contain an average, to the gallon, of *organic substances*, 2.3463 grains; *mineral substances*, 9.7587 grains; undissolved or *sedimentary matter*, 2.3745 grains, and some gaseous matter.

As relates to metres, the most troublesome of these is the sedimentary matter; consisting of sand, mud, and vegetable substances.

In many metres, containing water-tight packing and chambers—such as a piston or plunger working in a cylinder—the sand cuts out the packing and allows the water to escape, while the mud and vegetable substances accumulate within all the chambers, and ultimately choke the metre, and wholly interrupt its operation. Several patents have been granted for inventions intended exclusively to relieve metres from this accumulation of sediment, but without success; while no public water is so free from sand and grit as not soon to cut away any metal or packing coming in such contact as to cause friction.

It is well known that the combined action of sand, water, and friction is employed in the mechanic arts for the very purpose of cutting, grinding, and polishing—of course, it will have these effects on water metres. It would not be expected that the piston and cylinder of a steam-engine would durably operate, thus supplied with mud and sand. Why should water metres? These impediments, caused by sediment, cannot be avoided in that class of metres—embracing the majority of all metres—which depend, for their operation, upon water-tight fittings and compartments. Such metres cannot, either, long endure this cutting and grinding process. They will soon fail. Anything submitted to the combined action of sand, water, and friction must soon wear out.

2d. The difficulty of rendering Metres sufficiently durable.

This difficulty is one growing out of the first, viz.: the presence of gritty matter in the water. As this point was anticipated in what has just been said, it is not necessary to further allude to it.

3d. The difficulty of securing sufficient accuracy of measurement.

Metres acted upon by a head of water, varying from one foot to two hundred feet, and by streams, varying in size from the smallest to the largest that can be drawn through faucets and supply pipes; causing the metre to run, at times, with great rapidity, and at others with scarcely a perceptible motion. When it is considered, then, what extreme variations of head and size of stream, water metres are subjected to, it is not strange that the greater proportion of them should signally fail to adapt their movements to these variations, so as to indicate the precise quantity of water that passes through them.

4th. The difficulty of rendering Water Metres sufficiently simple and compact.

As heretofore constructed, metres, generally, are too complicated and bulky. Metres depending upon the action of combinations of machinery are too liable to wear out, to become disordered and require expensive repairs. This is *particularly* the case with water metres, because of the corrosion, sediment, etc., always attending the presence of water, together with the fact, that they are necessarily subjected to great pressure and rapid and forced action, while their great *bulk* precludes the possibility of making them of non-corrosive metal, without too greatly increasing their cost.

5th. The difficulty of constructing Metres so as not to obstruct the flow or head of water.

The *head* of public water is, so to speak, one of its most essential elements or conditions. In some instances a head of a very few feet, more or less, supplies or de-

prives half a city. Besides: much water is used under *full* head for jetting purposes. Yet nearly all metres—all those depending upon water-tight packing, or that have other friction to overcome—necessarily obstruct the flow. If there be any friction at all, about the operation of a water metre, it will commensurately obstruct the head. Therefore, it is a desideratum to have a metre work with the least possible friction.

6th. The difficulty of rendering Metres sufficiently inexpensive for general use.

The water metres heretofore offered, at a price that can be afforded, are worthless, while those that can make any claim to durability and accuracy of measurement are too expensive, especially for private houses, and too liable to need costly repairs.

To avoid all *accumulation of sediment*, the metre must be so constructed as not to produce chambers and eddies, or still water, within itself. It must be open and direct, that the water may have as free and straight course through the metre as possible—carrying along with itself every particle of dirt. In fact, no metre, by the very nature of things, can keep free of sediment, that would not wash itself of all mud and dirt that might be purposely placed in it—even if it were filled full with a view of obstructing its operation. If it cannot wash out mud purposely placed in it, it will most certainly *accumulate* mud.

To prevent all *obstruction to the flow or head* of the water, the metre must be as free from friction, and every other obstruction, as possible. It must require no per-

ceptible force to move it. It should yield to the action of the water as sensitively and freely as a feather to the wind. The *inertia* and *momentum* should, also, be as little as possible. The metre should start with the *first* and stop with the *last* motion of the water.

Simplicity is the first merit in any machine; particularly in a water metre. A water metre should, if possible, be as free from complication as a simple wheel. It should occupy but little space, as many times there is but limited room to apply it. It should be light, that it may be made of composition, to avoid corrosion. It should be so constructed as to be easily attached and detached.

With reference to simplicity in the construction of water meters, it seems as if inventors, generally, had gone wide of the mark.

A water metre should be perfectly *accurate* under all circumstances; whether the *head* and *volume* be great or small; or the volume great, and head small; or head great, and volume small. The same number of gallons should always produce the same metrage on the dial

The very nicest accuracy may not seem absolutely necessary, however, when we consider that the actual cost of water is but *eight mills per* 100 *gallons.* A deviation of a pint or so, on 100 gallons, would not be deemed of much consequence, one way or the other.

To render a metre *durable*, there must be no rubbing or friction of parts, at least, large surfaces, coming in contact with the water; otherwise the grit and water will soon grind them out of working order.

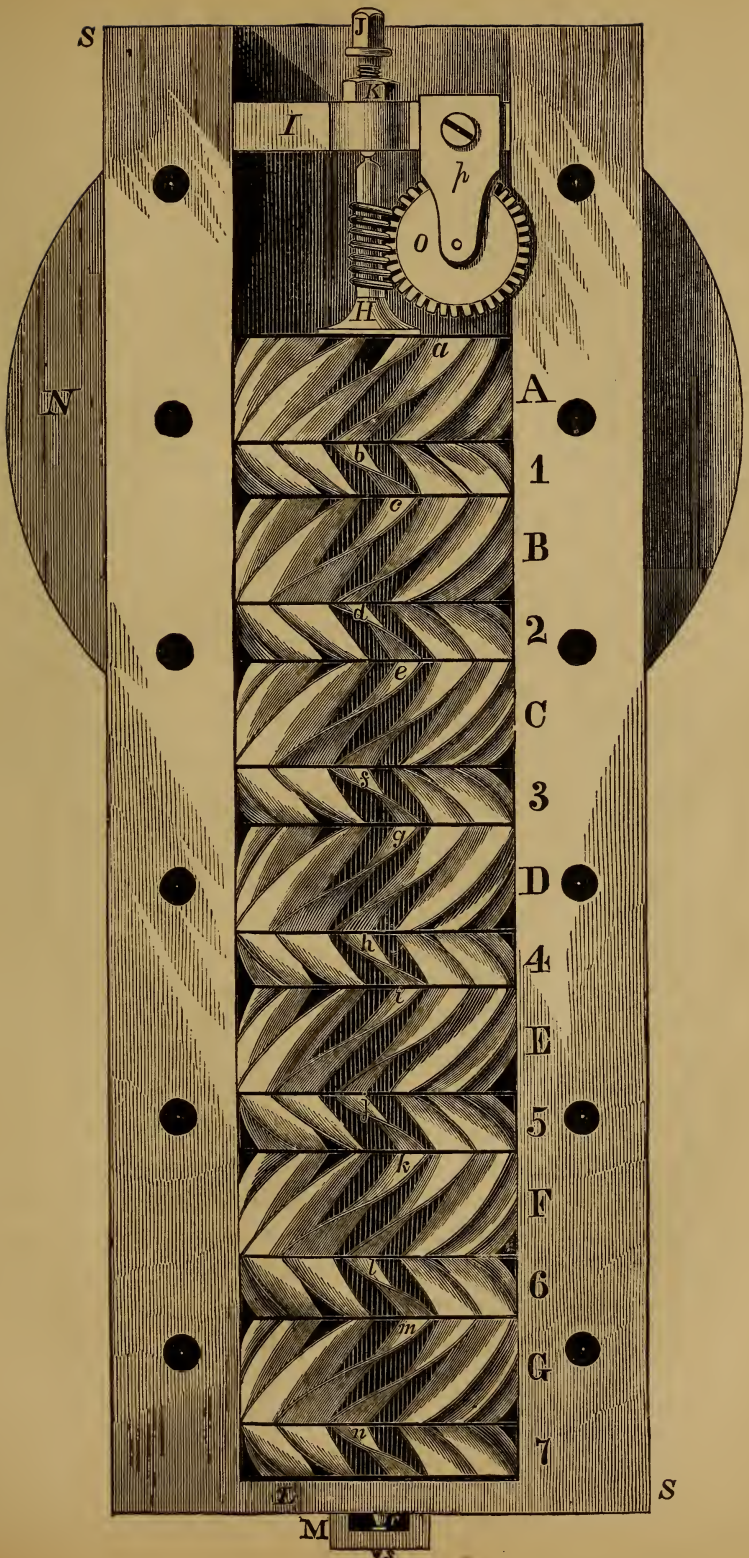
DESCRIPTION OF FRANK G. JOHNSON'S TURBINE COMBINATION WATER METRE.

PATENTED JANUARY 1, 1861.

Fig. 1 represents a perspective view of the metre, of nearly the actual size for a common house. *S* is a cylinder made in two halves, and held together by means of bolts and side flanges; the inside being bored out perfectly straight and plain. *R* is the registering chamber, having no connection with the interior of the cylinder, save only by a hole an eighth of an inch in diameter, passing through its base, *N* (Fig. 2), to admit the shaft of the wheel *o*. *O P* are ordinary coupling nuts to connect the metre to the conduit or supply pipe. The front of the registering chamber consists of very thick plate glass.

Fig. 2 represents the interior of a metre of actual size for a common house, showing one-half of the cylinder and the base of the registering chamber. The half of the cylinder that is removed is perfectly plain. *H* (Figs. 2, 3, and 4) is a simple shaft, provided with a worm-screw at the upper end, to connect it with the registering wheel, *O*. This shaft is held in its place by straight, narrow strips or braces, *I* and *L* (Figs. 2 and 3), passing across the centre of the cylinder and being fastened to its sides, in such a manner as not to obstruct the flow of water through it. This shaft is adjusted and revolves on two pins, *t* and *r* (Fig. 3). As the metre is always placed in a perpendicular position, the weight of the shaft rests on

Fig. 2.



the lower pin, *r*. This pin stands on the base *s*, which is supported by the brace *M*. *J* is an adjustable screw to hold the upper pin, *t*. As will be seen, this shaft is now perfectly free to be revolved.

Fig. 4 represents transverse sections or end views of regular lathe-cut screws of deep, narrow threads — full size—the threads being of such a pitch as to make an angle of forty-five degrees with the central line. These two screws are cut reversely to each other, otherwise they are alike. They are hollow at the centre, the solid metal being all cut away, except a mere shell to hold the threads at their base; shown by the white circular lines in *A* and 1 (Fig. 4).

These screws are made in long pieces, and afterwards cut up into short sections, as shown in Figs. 2 and 3.

These sections or hollow screws are placed *in* the metre, and *on* the shaft, in the following manner: As shown in Fig. 2, the pieces, *A*, *B*, *C*, *D*, *E*, *F*, *G*, are simply laid into the cylinder at regular intervals from each other, and firmly clamped and held in place by bolting the two halves of the cylinder together, which brings the edges or periphery of the threads into water-tight connection with the inside of the cylinder, otherwise they do not come in contact with any part of the metre; the hole through them being sufficiently large to surround the shaft without contact; as shown in the drawing, *A* (Fig. 2), the black line representing the space between the shaft *H* and shell or hub of the screw. As will be seen, these sections of hollow screw do not at all obstruct the free rotation of the shaft. *These* pieces of hollow screw we term, for convenience, sections of *spiral water-passages*.

The sections 1, 2, 3, 4, 5, 6, and 7, are firmly fastened, water-tight, on the shaft at regular intervals from each other, so as to come between the sections of spiral water-passages, *A*, *B*, *C*, &c. These sections 1, 2, 3, &c., revolve with, and are a part of, the shaft. As there is space enough left between these and the other sections, and between the edges or periphery of these sections and the inner surface of the cylinder, to avoid contact, the shaft is as free to rotate as before. These sections 1, 2, 3, &c., we term, for convenience, *motors;* and the threads, *motor-blades.*

Fig. 5 represents the interior of the *cylinder S*, the sections of *spiral water passages A, B, C*, * * *, and the *motors* 1, 2, 3, * * *, laid out on a flat surface, which exhibits the threads of the screws in the form of inclined planes, respectively as they are lettered. The arrows represent water. *S S* represent the sides of the cylinder.

It will be seen that no water can now pass through the metre without passing through the spiral water-passages *a*, *c*, *e*, *g*, *i*, *k*, *m*, formed by the threads of the sections *A*, *B*, *C*, etc., or without passing over or between the *motor-blades*, *b*, *d*, *f*, *h*, *j*, *l*, *n*.

These *spiral water-passages* and *motor-blades* cross each other at right angles.

OPERATION OF THE METRE.

The *operation* of the metre is thus described, reference being had to figures 2 and 5:

As water comes through the supply pipe and into the metre it moves in straight lines, parallel to the sides of the

Fig. 3.

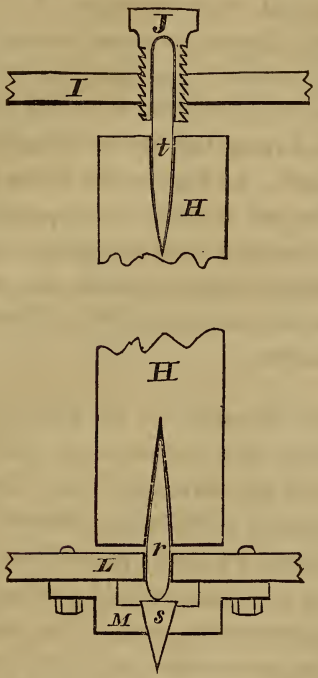
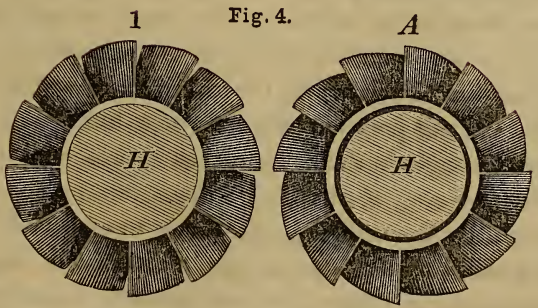


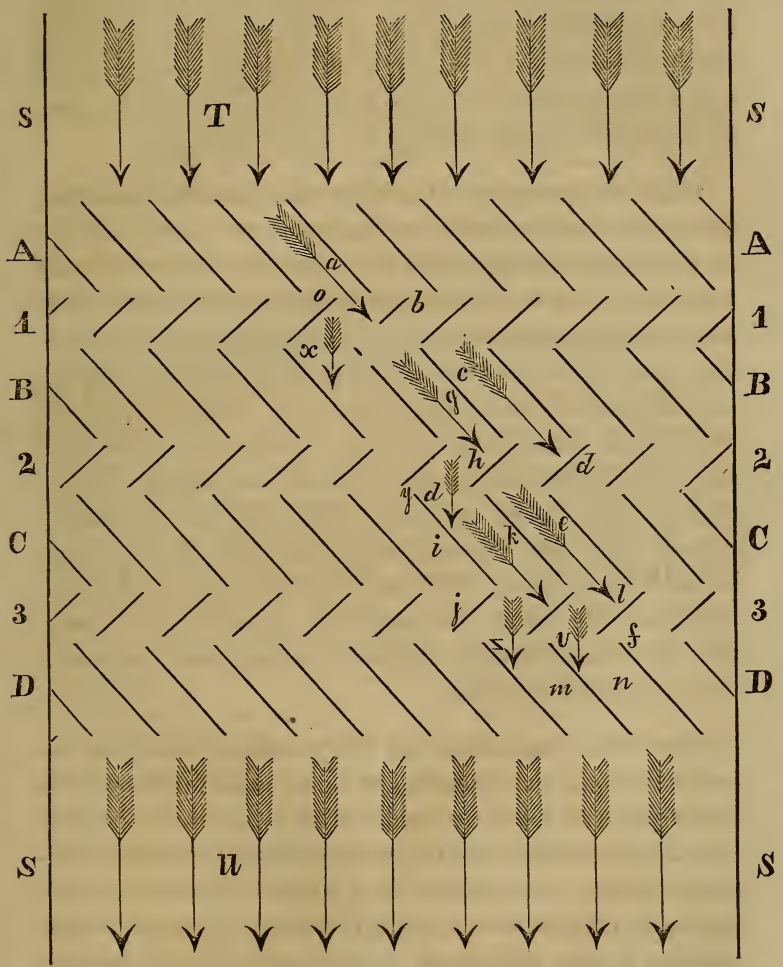
Fig. 4.



pipe and metre, as shown by the arrows *T* (Fig. 5), until it reaches the spiral water-passages *A*; it then passes through these and is forced to come in contact with the motor-blades on section 1, at perpendicular, instead of oblique, angles to their surfaces, which is the most favorable direction for driving the blades along and so rotating the motors and shaft. As soon as the water passes motor 1 it re-enters another set of spiral water-passages, and thus is forced to come in contact with the motor-blades on section 2, in the same manner that it did on the motor-blades of section 1; and so on, through all the different sections, until it leaves the metre.

Again: suppose the shaft to be held by force and not allowed to revolve, then the water, as will be seen, must follow the course of the threads of both kinds of sections, and thus turn as quick as lightning, almost, at *right angles*, out of its course, every time it passes from one section to the other. This, of course, would produce very great reaction on the motor-blades; but, if the shaft be free, as it is, to rotate, the *motor-blades* will be driven before the water, and the water will pass around in a spiral direction as it goes through the metre, in the same manner that it would follow a similar screw if it were *continuous*, and not cut into *sections*. In figure 5, the water, represented by the arrow *T*, will not pass directly *down* to *u*, but it will follow the water passages in their courses, as represented by the oblique arrows *a*, *g*, *c*, etc. To be more minute, the water, represented by the arrow *a*, will strike the motor-blades *o* and *b*; *o* and *b* will move on, and most of the water, *a*, will pass on to *g*, while the least possible quantity of it will be turned *off* in the direction of *x*; the same water, *a*, will now pass from *g* to *c*, and so on to *f*, and, finally,

Fig. 5.



around and through the metre; at *p* a little more will be turned off in the direction of *d* into *k*, and then a little more in the direction of *z* into *m*. The amount of water that will be turned off or out of the natural course of the spiral water-passages must be infinitesimally small, because the shaft offers comparatively but little resistance.

With whatever power the water acts upon the 1*st* motor, the *same* water acts with the *same* or equal power on the 2*d* motor, and the 3*d*, and so on. But were there an equal number of sections of these motor-blades on the shaft, without the intervening sections of water-passages, the water, after passing two or three of them, would get to rotating *with* the motors, and so lose its force to rotate any of the others as it *passes* them. But by intercepting these sections of spiral water-passages *between* the motors, and securing them to the cylinder, *action* and *reaction* are as powerful to rotate the shaft on the *last* and all *intervening motors* as on the *first*. Each motor is thus made, with the same flow of water, to contribute equally to overcome one common resistance, without *increasing* that resistance to any perceptible extent.

The shaft is made large for the purpose of filling up the central part of the cylinder, so as to make the threads or water-passages less deep than would otherwise be needed, and by which means *all* the water is made to come in contact with the motor-blades at a greater distance from the centre of motion, which gives the same amount of water stronger action, and causes the aggregate of the blade-surface to pass through more equal distances.

By the *repeated* combinations of these reversed screws or spiral water-passages and motors, the *action and reaction* are

so much *multiplied* that the motors become exceedingly *sensitive* to the motion of the water—*as much so as a feather to the wind.* Thus the revolution of a *simple shaft* is rendered so sensitive to the action or motion of water, that the water is accurately measured by flowing through a simple pipe or cylinder a few inches long, and about an inch and a half in diameter.

DURABILITY OF THE METRE.

All the parts of the metre which are subject to wear are shown in Fig. 3. These are the bearings, *t*, *r*, and *s;* which, in the drawing, are some larger than *actual* size. All parts of the entire metre are made of tough "composition metal," except these three pieces, *t*, *r*, and *s;* which are hardened steel, chilled iron, or composition, with agate points.

There is no friction by metal rubbing against metal, in any part of the metre, except in connection with these three bearings; and of these the principal part of the friction and wear is between *r* and *s*. The *side* action and wear on the bearings *t* and *r* is merely nominal, as they sustain no force or resistance. The top of the base *s* is a flat polished surface; the bottom of *r* is a smooth *oval* or *round*. Hence the working contact surface of metal to metal is reduced to an absolute *point*.

When the metre is running at moderate or slow speed, the wear is next to nothing—with such speed it would never

wear out, if properly made. But the difficulty has been to make rotary metres stand the *high* speed which the head or pressure of water gives them. This metre, however, involves a principle peculiar to *itself*, which protects itself against racking wear and tear of high speed; in fact the *higher the speed* the *less the wear and tear* (save on the lower point). This principle is thus explained. The water being forced or carried around on the outside of the central portions of the metre, if *moving at a rapid speed, has the effect to crowd the shaft and its motors to the common centre, and take the side pressure or action entirely off of the side bearings t and r.* Therefore, so far as any essential wear is concerned, it is *all* reduced to one almost mathematical point—the contact between *r* and *s*. This contact covering but a mere point, of course the bearings—that is, the bottom of *r* and top of *s*—may be made of materials of the hardest and finest quality—even diamonds could be afforded. Still, hardened steel, chilled iron, or agate, is good enough.

The metre standing *upright*, there is another cause which protects the side bearings from wear. It is thus explained. If a common *top* be placed in a horizontal position, and firmly held at its two extremities by suitable bearings, and then made to revolve at high speed, these bearings will be subject to wear from two causes, one of which is the friction necessarily produced by the gravitation of the top; the other is that peculiar trembling, shaking or knocking action produced by the high speed of small bodies, not more perfectly balanced than it is possible to make them; yet it is well known that this top, if it were placed in its proper *upright* position and kept running at the same high speed, the *side* bearings would be *entirely* relieved, and could be taken entirely *away*, and yet the *top* itself would continue

to revolve, wholly unsupported, save by its velocity and the *single point* of contact on which it stands. In fact, the greater the velocity the more firmly and steadily the *top* keeps its position, independently of side supports. What is true in this respect of the *top* holds good with *this metre;* that is, when the metre runs at a speed that would materially *wear* the side bearings, it assumes an upright position and "stands alone" independently of side supports; which, as we said before, concentrates the wear and tear to a mere point.

From the above illustration it will be apparent that the metre offers no perceptible resistance to the water, and that it operates with the most perfect freedom. The motors can be revolved *two thousand times* at a single breath, representing the measurement of about *fifteen* gallons of water.

The freedom with which this metre runs—its simplicity and, therefore, little liability to need repairs—its little wear, and consequent durability, are all well illustrated by the construction and operation of a common *top.*

It does not in the least obstruct the flow, or lessen the head, of water.

The foot *r*, standing upon a mere point, *there is no chance for sand or grit to get between working contact surfaces; hence, no part of the metre is ground out of order by sand and friction.* One of these metres (for a common house) has had run through it 500,000 gallons, which, at 30,000 gallons per year, would supply a dwelling nearly *seventeen years;* yet the metre, when examined, even by a microscope, does not show the least wear, save the smallest possible

indentation on the base, *s*. The *oval*, or bottom of *r*, remains round and smooth as when first made. *Except on this point of contact at the bottom of r, there is no more wear on this metre than there is in a common pipe by water running through it.*

There is no chamber or recess where sediment can accumulate. In fact, the metre may be *filled* with mud, sand, and what not, and the first flow of water will clean it out entirely.

The *accuracy* with which this metre measures water may be seen from the following extract, taken from an article in the "Brooklyn Daily News," of Aug. 7, 1862.

* * * Yesterday afternoon a number of gentlemen, interested in mechanical improvements, assembled at No. 121 Willoughby street, to witness the trial of a new water metre, invented and patented by Dr. Frank G. Johnson. * * *

The metre was tested *in every manner*, with the *most satisfactory results* to the gentlemen present, and was found to work with *unerring accuracy under all circumstances.* The test of delivery through the discharge pipe, with different nozzles, was made with the following results :

Size of nozzle.	No. of galls.	No. of turns of metre.	Head of water.	Time. M. S.
8–16 inch.	20	2,740	110 ft.	2 56
7–16 "	"	"	"	3
6–16 "	"	"	"	3 4
5–16 "	"	"	"	3 13
4–16 "	"	"	"	3 28
3–16 "	"	"	"	3 55
2–16 "	"	"		4 40

RESULT WITHOUT HEAD OF WATER.

The metre being attached to the receiving-cask, the measurement was as follows :

Size of nozzle.	No. of galls.	No. of turns of metre.	Head of water.	Time. M.	S.
8–16 inch.	20	2,740		4	7
7–16 "	"	"	Nothing save	4	25
6–16 "	"	"	pressure of	5	30
5–16 "	"	"	the water	6	5
4–16 "	"	"	in the cask.	9	
3–16 "	"	"		12	
2–16 "	"	"		18	

COST OF REPAIRS OF THE METRE.

By referring to Fig. 3, it will be seen that the parts which are at all subject to wear, *t*, *r*, and *s*, can be easily removed, and new ones put in their places, at *a shilling's expense*, which renders the metre, however much it may be worn, as good as an entirely new one. The pins *t* and *r* are simply pulled out of the shaft *h*, and new ones driven in. The base, *s*, is a small inverted cone of steel (or other hard substance), dropped into a corresponding hole in the brace, *m*. This cone can be taken out and a new one put in, as also the pins *t* and *r*, by means of only a pair of nippers. The cost of renewing these parts, after the metre is detached from the supply pipe, need not be over one shilling. The metre can be placed on the supply pipe so as to have the water run *down* through, or *up* through it, as may be most convenient.

The registering apparatus can be arranged so as to need inspecting only once in a month, quarter, or year, as may be desirable.

The dial, in the drawing, opposite to *I*, in the centre, indicates *one* gallon at each revolution of the pointer—the one opposite to *X*, ten gallons—the one opposite to *C*, one hundred gallons, and so on.

Relative importance of different merits in Water Metres.

Of several differently constructed water metres, it will be claimed, perhaps, that each has some merit or merits which the others do not possess. It will be claimed for one, that it is more *accurate;* for another, that it is more *durable;* for another, that it is not liable *to fill up with sediment*, and so on. Of these, and other qualities, there are some more indispensable than others. For instance, a metre that will *soon fill up with sediment* is of no account. To be practicable, it must keep itself entirely free of sedimentary deposits. A metre which *costs* too much to be afforded, though it may possess all other merits, is practically useless. A metre which, from complexity or peculiar construction, is liable to *stop* by disarrangement, would not be *reliable*, though it might cost but a trifle to put it in order again; or a metre which is rendered very *expensive, by needed repairs*, is also impracticable, whatever be its other merits. Again: a metre that materially *obstructs the flow or head of water*, though it possess all other merits of a good metre, is practically worthless. *Clearage, reliability, non-obstruction to the flow or head of water, reasonable cost, durability, and cheapness of repairs* are INDISPENSABLE qualities in a practical water metre. Any metre essentially wanting in *either* of *these* merits, however desirable it may be in other respects, is *impracticable and useless.* A water metre, combining all these qualities, must be con-

sidered a practical machine and a desideratum ; provided it will *measure* or indicate the quantity of water passing through it, with practical *accuracy*.

It is contended by some that a metre should measure water with as much accuracy as if it were *gold* or *poisonous drugs*. Yet, when it is considered that the *actual cost* of water is only *eight mills per one hundred gallons*, it is absurd to demand such extreme accuracy of measurement— *especially* is it absurd when it is considered that *now*, without metres, *sixty per cent.* of all the water is wasted.

Calling for such mathematical accuracy, under these circumstances, is equivalent to demanding *perfection*, or accepting *chaos*.

Metres are often put to the "drizzle test" and condemned if a few drops or pints of water can be got through them without being measured; yet metres are never *used* in this *way ;* and if they *were*, a few pints or quarts of water wasted or unmeasured would not practically affect the income or consumption of water.

No machine is *mathematically* perfect — not *one watch* even, in a thousand, is a *perfect* "*time-keeper*," while, perhaps, there are not half a dozen in the thousand that do not *practically* serve the purposes of "keeping time."

THIS METRE ADAPTED TO OTHER PURPOSES.

This metre, *requiring no "head" of water to work it*, is admirably well adapted to the measurement of other liquids besides public water, as all kinds of dyes, ale, lager beer, alcohol, and other liquors, and all kinds of oil, &c., &c.

It is well known that vast quantities of these articles, for the purpose of measuring them, are handled at *great disadvantage*, requiring much time and expense, which can be avoided by the use of these metres. They can, for this purpose, be made very small and cheap. They need not be larger than a half-pint bottle. To measure a vat or cask of any of these liquids, it is only necessary to screw the metre on to the bottom of the vat or cask, or place the metre between the ends of two pipes, or connect it by a hose; in short, any way to cause the liquid to pass through the metre, and then merely allow the liquid, by its own gravity, to flow from one vat or cask to another; which process—having noticed the starting point on the dial—can go on as well *without attendance as with.*

The exceeding *cheapness* and *convenience* of this method over any other must be evident; *the metre being a sort of measuring faucet, which measures the liquid by its merely passing through it.*

Besides, there are some articles, as kerosene oil, which are very *unpleasant to handle;* while others, as alcohol, turpentine, &c., are *wasted by evaporation* when exposed in

open measures. In fact, *all* liquids are more or less wasted by the present method of measuring.

The *accuracy* of this metre for this purpose is *complete!* A given vat or cask of liquid, great or small, may be drawn through it, any number of times, and the metre will distinctly indicate a deviation as small as a *tablespoonful* even, and show whether it has been *added* to or *taken from* the cask.

This metre, by suitable modifications of the exterior, is also well adapted to the use of vessels for *measuring the depth of water at sea.*

It may also be very conveniently employed to *test and register the speed of vessels.*

THE WATER METRE,

AND THE

ACTUAL MEASUREMENT SYSTEM

OF

CHARGING FOR PUBLIC WATER.

BY

[illegible] O. JOHNSON, M. D.

[illegible]

[illegible]

NEW YORK:
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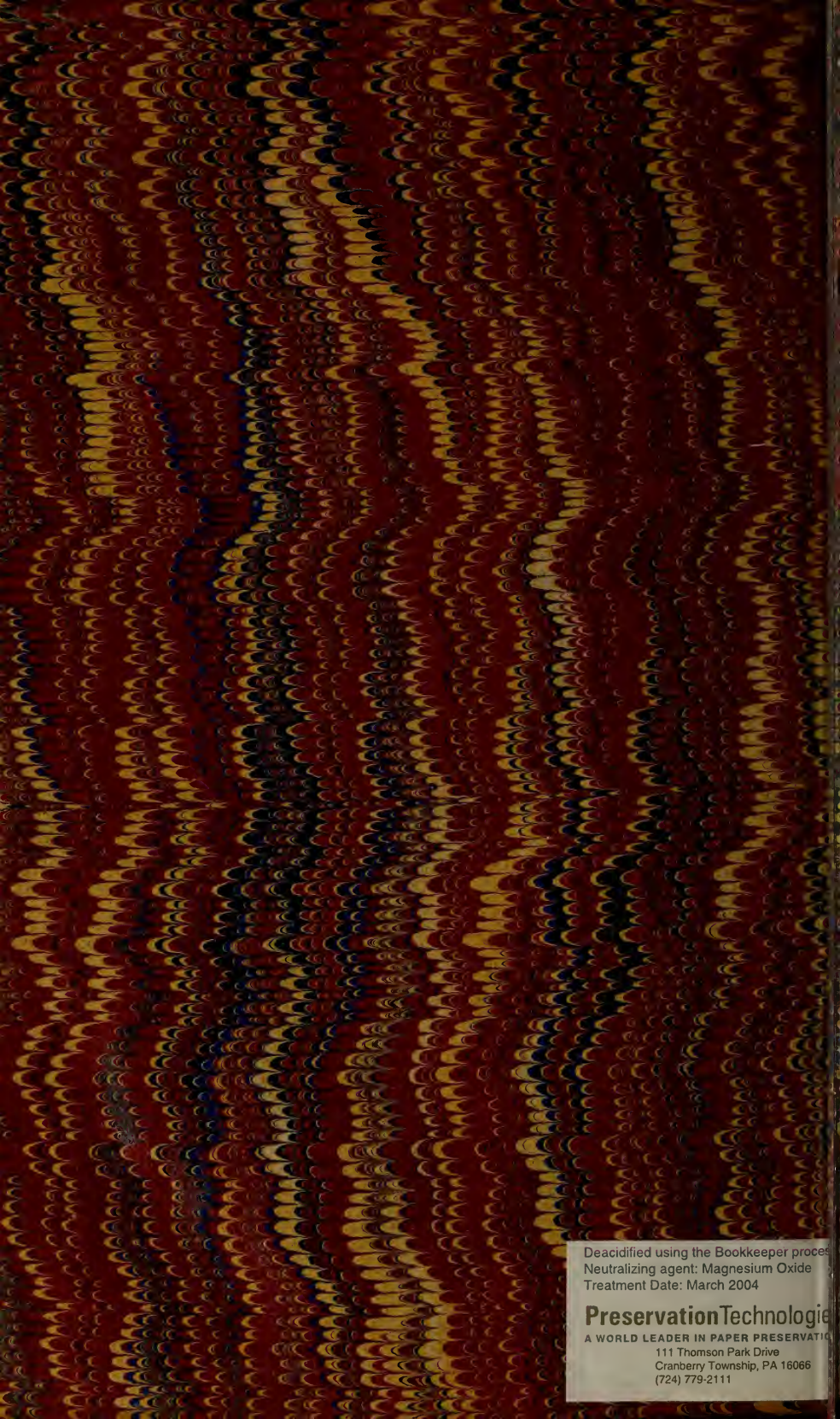
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